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THE Αὐλός OR TIBIA.

BY ALBERT A. HOWARD.

THE Greek name αὐλός, Latin *tibia*, was applied, in ancient times, to a variety of wind instruments of music, consisting of a tube in which the air-column was caused to vibrate by the breath of the performer.

At least three distinct types of such instruments are easily conceivable, — the simple tube in which the sounds are produced by blowing across the open end of the tube, or across an opening in the side of it; the tube into one end of which a reed mouth-piece is inserted, and in which the air-column is caused to vibrate by blowing through the mouth-piece; and the third type, in which the lips of the performer, pressed against the open end of the tube, form the reed by which the sound is produced. All three of these types of instruments were known to both Greeks and Romans, but not all such instruments were, technically speaking, αὐλοί. The syrinx, or pan's-pipe, was an instrument of the first type, but was not called an αὐλός; and the instruments of the third type were perhaps never called αὐλοί, the common name being Greek σάλπιγξ, Latin *cornu* or *tuba*. Instruments of the first and second types called αὐλοί certainly did exist, as will be shown in the following pages.[1]

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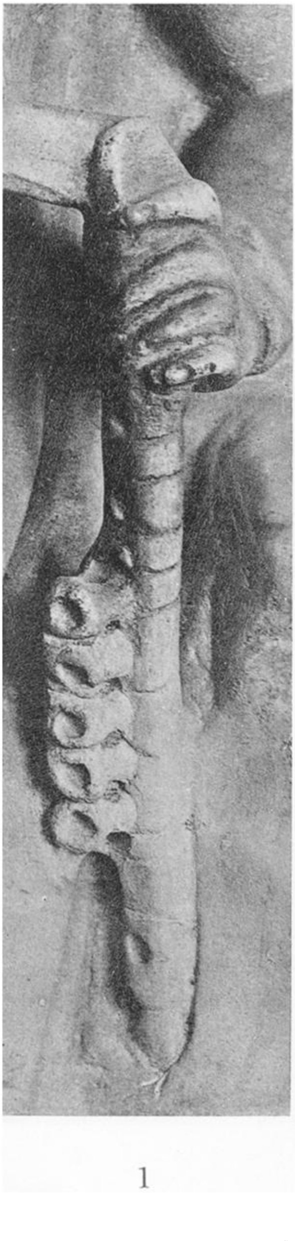
[1] Probably no type of this instrument was, in its primitive form, the invention of either Greeks or Romans. The Romans believed that the art of playing on the tibia had come to them from Greece, for Ovid, F. VI. 662, calls this art the *ars Graia*, and even the names of the different varieties of instruments, as Phrygian, Lydian, etc., indicate Greek origin; while among the Greeks the tradition points in most cases to an Asiatic origin for the instrument (cf. Plut. de mus. ch. V., Pollux IV. 74 sq.), and Egypt is distinctly stated to have been the home of one or two types of the instrument. Cf. Pollux IV. 74–75, etc.

The instrument in several different forms was known to the Egyptians in very early times, as is shown by the representations of it in their works of art, and the Assyrians also knew and used the double pipe at least 700 years before the Christian era. The existing remains of Egyptian pipes have been described at length by Victor Loret, Les flûtes Égyptiennes antiques, Journal Asiatique, 1889, pp.

PLATE I.



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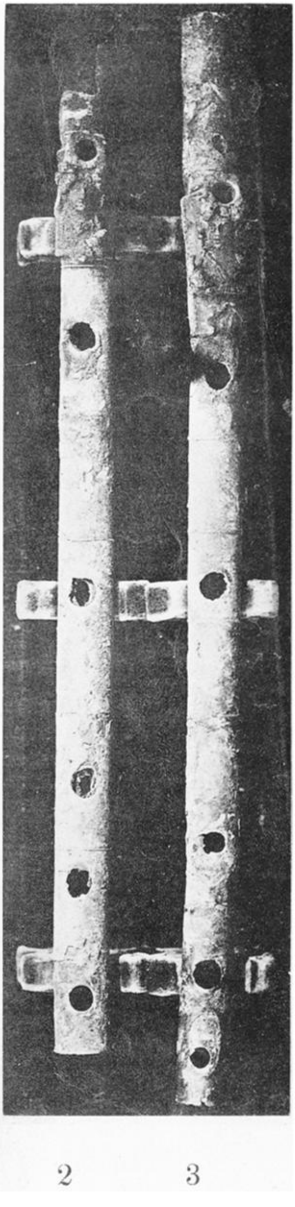

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All of these instruments may be classed, according to their acoustic properties, as 'open' or as 'stopped' pipes. An open pipe gives the complete series of harmonics, the octave, the twelfth, the double octave, and the third above the double octave of the fundamental tone of the pipe. A stopped pipe produces a fundamental tone one octave lower than the corresponding tone of an open pipe, but gives a series of harmonics including only the twelfth and the third above the double octave of the fundamental tone.

FINGER-HOLES, THEIR POSITION AND NUMBER.

The notes of the musical scale lying between the fundamental tone of the pipe and the first harmonic can be produced only by opening, in the side of the pipe, holes of proper size at appropriate distances from the end of the pipe and from each other. To produce the diatonic scale through continuous octaves, beginning with the lowest register of the instrument, six such holes are required for an open pipe, eleven for a stopped pipe. To produce the chromatic scale even more holes are necessary. Theoretically, the position of each of these holes for a given scale can be mathematically determined, but in practice the position of the holes is largely determined by experiment, and the holes are often slightly out of place, the result of which is a defect in the pitch of every note dependent on a hole improperly placed. But every performer on a wind-instrument has it in his power, by means of well-known devices, to correct minor defects in the pitch of his instrument caused by improper location of the finger-holes, and, no matter how perfectly his instrument is constructed, he is under the necessity of making these corrections in pitch. That this was equally true of ancient artists and instruments is apparent from a passage in Aristoxenus (ed. Marquard, p. 60, chap. 42–43).

The extent to which the pitch of a note can be altered by these various devices is, however, limited, and the proper position of the finger-holes, especially before the adoption of mechanical means for closing such holes as were not in use, must have been a very difficult problem for the ancients to solve. Doubtless many of the treatises mentioned in Athenaeus IV. 80 and in other writers dealt, at length,

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111 sqq., and wherever in this article Egyptian instruments are mentioned the facts are drawn from that source, unless statement to the contrary is made.

with this subject; one treatise mentioned by Athenaeus XIV. 36, the περὶ αὐλῶν τρήσεως of Aristoxenus, was perhaps devoted exclusively to this subject. This work comprised not less than two volumes, for the reference is ἐν πρώτῳ περὶ αὐλῶν τρήσεως, implying that, at least, a second volume existed. The loss of this treatise is all the more to be regretted from the fact that it was the work of such an eminent authority on ancient music.

No treatise on the boring of pipes has been preserved to us even in a fragmentary form, and I have found but two direct statements, in ancient writers, as to the proper position of the finger-holes. The first is from Aristotle, Prob. XIX. 23, Διὰ τί διπλασία ἡ νήτη τῆς ὑπάτης; ἢ πρῶτον μὲν ὅτι ἐκ τοῦ ἡμίσεος ἡ χορδὴ ψαλλομένη καὶ [ἡ] ὅλη συμφωνοῦσι διὰ πασῶν; ὁμοίως δὲ ἔχει καὶ ἐπὶ τῶν συρίγγων· ἡ γὰρ διὰ τοῦ μέσου τῆς σύριγγος[1] τρήματος φωνὴ τῇ δι' ὅλης τῆς σύριγγος συμφωνεῖ διὰ πασῶν. ἔτι ἐν τοῖς αὐλοῖς τῷ διπλασίῳ διαστήματι λαμβάνεται τὸ διὰ πασῶν, καὶ οἱ αὐλοτρῦπαι οὕτω λαμβάνουσιν, ὁμοίως δὲ καὶ τὸ διὰ πέντε τῷ ἡμιολίῳ. ἔτι οἱ τὰς σύριγγας ἁρμοττόμενοι εἰς μὲν τὴν ὑπάτην ἄκραν τὸν κηρὸν ἐμπλάττουσι, τὴν δὲ νήτην μέχρι τοῦ ἡμίσεος ἀναπληροῦσιν, ὁμοίως δὲ καὶ τὴν διὰ πέντε τῷ ἡμιολίῳ καὶ τὴν διὰ τεττάρων τῷ ἐπιτρίτῳ διαστήματι λαμβάνουσιν. ἔτι αἱ ἐν τοῖς τριγώνοις ψαλτηρίοις τῆς ἴσης ἐπιτάσεως γινομένης συμφωνοῦσι διὰ πασῶν, ἡ μὲν διπλασία οὖσα, ἡ δὲ ἡμίσεια τῷ μήκει.[2]

From this passage we learn that the finger-hole by which the octave was produced was bored in the middle of the tube; the hole to produce the fifth was so placed that the length of the entire instrument and the length of the portion above the hole should be in the ratio 3 : 2, and the hole to produce the fourth was so placed that the entire instrument and the portion above the hole should be in the ratio

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[1] The discussion of the syrinx here mentioned I have reserved for a later place in this article (page 19).

[2] The text of this problem in the various editions is in such condition that certain changes in words and in punctuation seem necessary in order to make the passage intelligible. The changes in punctuation are so obvious that they need no justification. I have inserted ἡ before ὅλη and have restored συμφωνοῦσι which is found in one Ms. in place of συμφωνοῦσα. For αὐλοῖς the Mss. read ἄλλοις and for ἔτι of the following sentence ὅτι; both of these changes were suggested by Aug. Wagener, as I learned after I had myself decided upon them. Finally αἱ must be read for οἱ in the Mss. in the last sentence, as is evident from the ἡ μέν and the ἡ δέ which follow.

4 : 3. Assuming that the finger-holes have a diameter equal to the internal diameter of the tube itself, these are the positions which they should theoretically occupy in an instrument of cylindrical bore.

The second statement is from a late Roman source, Favonius Eulogius in the commentary to the 'Somnium Scipionis' (Cic. ed. Bait. et Orell. Vol. V. pt. I. p. 412) : si tibiam cuiuslibet longitudinis sumas, et octaua eius portione deducta cauernam imprimas, tonus auditur; si sextam decimam ex reliqua metiaris hemitonium consequitur. This however is a mere 'rule of thumb,' and it is doubtless of late origin, since it implies the existence of a tempered scale in which all of the tone-intervals are equal, and in which the interval of the semitone is half as great as that of the tone. Even as a 'rule of thumb' this is too inexact, for instead of '*octaua*' we should have '*nona* eius portione deducta.'

From Macrobius, in Somn. Scip. II. 4, 5, we get the further information that not all finger-holes had the same diameter: nec secus probamus in tibiis de quarum foraminibus uicinis inflantis ori sonus acutus emittitur, de longinquis autem et termino proximis grauior, item acuta per *patentiora* foramina, grauior per *angusta*. This information is of value since it proves that the ancient instrument-makers were familiar with an important principle utilized to-day in the manufacture of wind-instruments, namely, that a hole of small diameter nearer the mouth-piece may be substituted for one of greater diameter in the position which the hole theoretically should occupy.

The earliest form of αὐλός, to whichever of the types of instrument mentioned above it belonged, must have been, from a musical point of view, a very imperfect instrument. Pollux, IV. 80, says that, until the time of Diodorus of Thebes, the αὐλός had only four finger-holes, and Acro,[1] in the scholion to Hor. A. P. 202, quotes Varro as having twice made the statement that the tibia anciently had only four holes, while others maintained that it had only three. No Greek or Roman pipes with only four finger-holes have, as yet, been found, although they are not infrequently represented in works of art; but unquestionably, until some mechanical device was employed for closing the holes not in use, the pipe, when used in pairs, cannot have had more than four holes, unless the thumb was used to close one hole.

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[1] Varro ait in tertia disciplinarum et ad Marcellum de lingua Latina, quattuor foraminum fuisse tibias apud antiquos, et se ipsum ait in templo Marsyae uidisse tibias quattuor foraminum, quare quaterna tantum foramina antiquae tibiae habuerunt; alii dicunt, non plus quam tria.

Of thirty-four Egyptian pipes described by Loret[1] twelve have but three holes each and thirteen only four holes each, while the primitive pipes of the various ethnological collections show, with few exceptions, four holes each, — indirect evidence which helps to confirm the truth of the statements of Pollux and Varro.

On an instrument with but four finger-holes it is, of course, impossible to produce a continuous scale beginning with the lowest register of the instrument. Either, then, this lowest register of the αὐλός was not used in the earliest times, or the musicians made use of a scale in which several tones of the lowest octave were wanting. In the absence of any direct testimony showing which of these methods was followed, any attempt to solve the problem is simply a matter of conjecture. Perhaps the simplest solution of the problem would be to assume that the notes of the pipe corresponded with the notes of the tetrachord, although in this case but three holes would be necessary, since on a pipe with four holes five notes can be produced. By neglecting the lowest register of the instrument and playing solely in the harmonics a complete diatonic scale can be produced on an open pipe with three holes, or on a stopped pipe with four holes, with the exception that on the stopped pipe the *octave* is a semitone too high.

It is, however, chiefly from the historical point of view that the determination of the scale of this simple instrument is of interest to us, for the αὐλός did not long retain its primitive character, but was constantly improved and perfected; in fact, the names of some of the artists by whom improvements were made have been preserved to our time. Diodorus of Thebes is said to have improved the αὐλός by increasing the number of finger-holes; Pollux IV. 80, πολύτρητον ἐποίησε . . . πλαγίας ἀνοίξας τῷ πνεύματι τὰς ὁδούς.

Whether or not this improvement was actually the work of Diodorus, the ancients certainly did possess αὐλοί with more than four finger-holes. This is clear, not only from works of art, but from the actual remains of musical instruments to be seen in various museums of Europe.

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[1] Journal Asiatique, 1889, pp. 197 sqq.

Probably the increase in the number of holes was not a large one at first, for in the existing instruments the number of holes varies from five to fifteen, and the αὐλός certainly did not reach its final development until a later period than that of Diodorus, as is shown by the statements of the ancients themselves. Pronomus, the celebrated musician and the teacher of Alcibiades, improved the αὐλός by making it possible to play on a single pair of instruments the three musical scales in use at that time, whereas before his time a separate pair of instruments was required for each scale. Pausanias IX. 12. 5, Ἀνδριάς τέ ἐστι Προνόμου ἀνδρὸς αὐλήσαντος ἐπαγωγότατα ἐς τοὺς πολλούς. τέως μέν γε ἰδέας αὐλῶν τρεῖς ἐκτῶντο οἱ αὐληταί, καὶ τοῖς μὲν αὔλημα ηὔλουν τὸ Δώριον, διάφοροι δὲ αὐτοῖς ἐς ἁρμονίαν τὴν Φρύγιον ἐπεποίηντο οἱ αὐλοί, τὸ δὲ καλούμενον Λύδιον ἐν αὐλοῖς ηὐλεῖτο ἀλλοίοις. Πρόνομος δὲ ἦν ὃς πρῶτος ἐπενόησεν αὐλοὺς ἐς ἅπαν ἁρμονίας εἶδος ἔχοντας ἐπιτηδείως, πρῶτος δὲ διάφορα ἐς τοσοῦτο μέλη ὑπ᾽ αὐλοῖς ηὔλησε τοῖς αὐτοῖς. This same story is told of Pronomus by Athenaeus XIV. 31, and although there are other ways in which this improvement could be effected, the simplest method would be to increase the number of finger-holes, closing temporarily such holes as were not required for the particular scale in which the musician wished to perform. It is also possible that some of the mechanical attachments to the instrument, which will be described later, were at this time brought into use.

In works of art of the later period the instruments are sometimes represented as provided with a large number of finger-holes, as for example in Plate I. 1, at the beginning of this article, which represents the pipe in the hand of a muse from a sarcophagus in the Louvre. This pipe has at least nine lateral openings. Of the Egyptian instruments described by Loret, two have five holes each, five have six holes each, one has eight, and one eleven holes. Of four Greek pipes in the British Museum three have six holes each, one five, and of the four pipes found at Pompeii in 1867 two have ten, one has twelve, and one fifteen holes. These instruments from Pompeii can very fittingly be called πολύτρητοι[1] or *multiforatiles*,[2] adjectives which are not infrequently used by ancient writers to describe the αὐλός or tibia.

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[1] πολύτρητος, Pollux IV. 80., Anth. Pal. 9. 266, 505. 5.

[2] Multiforatilis, Apul. Flor. 3, p. 341, Met. 10. 32; multifora, Ov. Met. XII. 158, Sen. Agam. 358; multiforabilis, Apul. Met. 10, p. 254, Sidon. ep. 8. 9.

BANDS.

When the number of holes in the pipes was increased to such an extent that the fingers could no longer close them all at the same time, naturally some device for closing the holes not in use had to be adopted. In the case of the pipes found at Pompeii this device consisted of bands of silver encircling the tube of the instrument, one for each hole, and pierced by a hole which corresponded exactly with the hole in the tube itself. These bands could be turned round on the tube and made to cover the holes in it, as is indicated by the position of the bands on the instruments as they were found. In some cases the band is so placed that the hole is open, and in other cases the hole is partially or entirely covered by the band. The bands are fitted neatly together, so that originally the whole body of the instrument was covered by them, and it is probable that Horace had in mind such an instrument when he says, A. P. 202, "*tibia non ut nunc orichalco uincta.*" Two of the pipes in the British Museum are also provided with metal bands, and the same is true of a fragmentary instrument in the same Museum; cf. C. T. Newton, Halicarnassus, Vol. II. pt. 1, p. 339.

Similar bands are represented in at least two reliefs on sarcophagi in the Louvre, one No. 240 of Fröhner's catalogue, representing a girl blowing on two pipes, each of which has a number of lines cut on it to represent the places where the bands join each other, although in this case no holes are represented in the bands; the second, Fröhner, No. 378, a sarcophagus representing the Muses with their attributes, Euterpe holding in each hand a pipe, the one in the right hand broken. The instrument in the left hand is shown in Plate I. 1, and the bands and the finger-holes in them can be easily distinguished. Perhaps the lines which are occasionally seen on the pipes in vase paintings are intended to represent these bands (cf. Baumeister's Denkmäler, Fig. 592, and von Jan's description). Not infrequently there is represented in works of art an additional device to enable the performer to turn the bands.[1] This device consisted of a hook-shaped projection from the surface of the band and seems to have been called

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[1] Relief in Naples Mus. No. 6684; relief in the Vatican, cf. Baumeister, fig. 598; sarcophagus in the Uffizi Gallery, Florence, representing contest between Muses and Sirens.

by the Greeks κέρας or βόμβυξ (cf. Arcadius de accentibus, p. 188, ed. Barker) ἀλλ᾽ ἑκάστῳ πνεύματι οὐκ ἀτέχνως οὐδ᾽ ἀμούσως τὰ σημεῖα ἐπέθετο· καθάπερ οἱ τοῖς αὐλοῖς τὰ τρήματα εὑράμενοι, ἐπιφράττειν αὐτὰ καὶ ὑπανοίγειν ὁπότε βούλοιντο, κέρασί τισιν ἢ βόμβυξιν ὑφορκίοις (ὑφολκίοις) ἐπετεχνάσαντο, ἄνω καὶ κάτω, καὶ ἔνδόν τε καὶ ἔξω στρέφοντες. ταῦτα οὑτωσὶ, κἀκείνοις ὥσπερ κέρατα τὰ σημεῖα ἐποιήσατο τῷ πνεύματι, ἕν τι σχῆμα ἑκατέρῳ σημηνάμενος. τοῦτο δὴ τὸ ἓν ὥσπερ αὐλῷ ἐοικὸς, ὅπερ ἔνδον καὶ ἔξω στρέφων ἐπιφράττειν τε καὶ ὑπανοίγειν τὸ πνεῦμα ἐδίδαξεν.

The κέρατα themselves are not in existence on any of the instruments which have been found, but the pipes from Pompeii have, attached to many of the bands, little sockets into which such arrangements could be inserted, and these sockets were undoubtedly intended to serve this purpose. Probably such a socket was originally attached to each band of these Pompeian instruments; the oxidization of the metal of the bands has, however, caused all trace of the socket to disappear in some cases, although on thirteen of the bands the sockets, or traces of them, are still to be seen.

The κέρατα are frequently shown in works of art in which bands are not represented on the instrument.[1] It seems reasonable to conclude in all such cases that the omission to represent the bands was due solely to careless work on the part of the artist, for without the bands the κέρατα would be useless. Furthermore, the frequent representation of the κέρατα is conclusive evidence that the bands were an almost universal addition to the instrument, although unfortunately the exact name by which they were called has not been preserved to us, at least in any recognizable form.

SIDE-TUBES.

Still another device is frequently represented in works of art, but has not been found on any of the instruments hitherto discovered. It consists of a short tube, often represented with a flaring end, directly over a hole in the pipe. This arrangement is often rudely represented in works of art, and has given rise to the theory that holes not in use were often stopped with a plug (cf. von Jan in Baumeister's Denkmäler, p. 557). That this arrangement is to be regarded as a tube and not as a plug is, however, shown conclusively in bas-reliefs;[1] for, wherever the sculptor has paid any attention to detail in his work, the hole in the tube is clearly represented, and inferences drawn from works of art in which the details are but rudely executed are, in the absence of literary evidence, of very little value.

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[1] This is notably the case in wall-paintings; e.g. Helbig Wandgemälde, Nos. 56, 69, 730, 765, etc.

On the whole, the representations of *αὐλοί* in works of art are as accurate as could be expected, for naturally the artists did not strive for absolute perfection in all the minor details of a musical instrument which played a very subordinate part in the entire work. Such care in detail as the artist has shown in representing the pipe in the hand of the muse in Plate I. 1, is exceptional, although of the greatest value to the student.[2] The fact, therefore, that the artists have so frequently represented these attachments as tubes is the best of evidence that they were regularly tubes, and not plugs to stop the holes. These tubes were sometimes, if not always, mounted on bands such as have already been described, and tubes thus mounted with a separate band for each tube are shown in the plate to which reference has been made. It is, of course, not impossible that such tubes were originally attached to the instruments found in Pompeii, and that the oxidization of the metal has caused all trace of them to disappear, although this is very improbable, especially if any considerable number of such tubes were in use on these instruments. The number of tubes represented on a single instrument varies from one to seven, the latter number occurring on the pipe of a muse in the British Museum and inaccurately shown in Millin, Galerie Mythologique, Plate XX. Fig. 64.

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[1] The following list includes only a few of the reliefs in which the holes in the tubes are represented: Paris, Louvre, Fröhner's Cat. No. 85 (photograph in H. d'Escamps, Marbres du Musée Campana, pl. 25); Fröhner, No. 378 (heliotype from photograph pl. I. 1, of this article); Munich, Glyptothek, No. 188 (reproduction from a photograph, Baumeister, fig. 1186); Rome, Lateran Museum, No. 751 (inexact engraving in Mon. dell' Inst. VI.-VII. 80, 2); Vatican Museum, sarcophagus representing Cupids as Muses (inaccurate engraving in Museo Pio Clem. IV. 15); Florence, sarcophagus representing contest between Sirens and Muses (cf. Baumeister, fig. 1704, from an engraving); London, British Mus., sarcophagus from Townley Coll. (inaccurate engraving in Anc. Marb. of the B. M. II. 35).

[2] Engravings of ancient works of art are, with few exceptions, very inaccurate in matters of detail, although they give, with sufficient accuracy, the main features of the original. Not one of the various engravings of the instrument shown in Plate I. 1, represents either bands or holes above and below the side-tubes of the pipe. In the Museo Pio Clementino, Vol. IV. pl. 15, the pipes held by the youth who represents *Euterpe* have each six side-tubes; in the original there are only four represented. In Millin, Galerie Mythologique, Plate XX. Fig. 64, Euterpe holds two pipes which might be mistaken for the rounds of a chair, while in the original one of the pipes has five side-tubes, the other seven, and the holes in the tubes are clearly shown. Even in such a work as the Museo Borbonico, Vol. XI. tav. 59, the female figure is represented holding pipes with five side-tubes, while in the original only four are shown. Wherever in this article reference is made to a work of art, I have seen either the object itself or a photograph of it, and have not depended on the engravings.

The words of Pollux quoted above, p. 5, probably refer to this very device: *πλαγίας ἀνοίξας τῷ πνεύματι τὰς ὁδούς*, for surely the words *πλάγιαι ὁδοί* might well be used to describe these tubes.

There is no direct evidence to show that the bands on which these tubes were mounted could be turned round on the pipe so as to cover the holes in it, but it is almost impossible to conceive that they could not be thus turned, for not only are the tubes occasionally mounted on separate bands as in our plate, but the *κέρατα*, or arrangements for turning the bands, which have already been described, are often shown on works of art in connection with the tubes, and occasionally, as in the relief from Zoega, Baumeister's Denkmäler, Fig. 594, there is such an arrangement corresponding to each of the tubes.[1] The effect produced by these tubes when in use would be to lower the pitch of the pipe, for the tone would be produced at the outer end of the tube and not, as ordinarily, at the surface of the pipe.

A somewhat similar arrangement is to be found on some of the Boehm flutes manufactured in England, and is described by E. S. Rockstro in his book on the Flute, p. 183. The C♯ hole of the ordinary flute serves both as a note-hole in producing C♯ and as a vent-hole in producing several other notes. It is ordinarily placed near its proper position as a vent-hole, which is somewhat nearer the embouchure than the proper position of the C♯ hole, and the diameter of the hole is diminished to allow the production of C♯, as a result of which the intensity of this note is weakened. To remedy this defect, in the flute described by Rockstro, the C♯ hole is bored with nearly the same diameter as the other holes, in its proper position as a vent-hole, and into this hole a short tube is inserted. The note C♯ is produced by the combined length of the flute to this point and the tube, but when the hole is used as a vent-hole in producing the harmonics, the connection with the outer air is of course at the bottom of the tube, and the length of the tube does not influence the sound.

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[1] This relief I have not seen, but in the following wall-paintings which I have seen there is a *κέρας* for each tube: Helbig, Nos. 730, 765, 1140.

The pipe held by the muse, Plate I. 1, shows five of these tubes and in addition several bands with holes but without tubes, from which it must be inferred either that the tubes could be attached to the instrument and removed from it at the will of the performer, or that only certain holes of the instrument were provided with this arrangement. There is no direct evidence by which this point can be settled, but in case the tubes were permanently attached to the bands there would be no satisfactory reason for their existence, unless the band was provided with a second hole, which could be brought into use by turning the band until this second hole, and not the tube, covered the hole in the instrument. There is nothing in any of the reliefs to indicate the existence of a second hole, but in Proclus (comm. in Alcibiad. p. 197, ed. Creuzer) the statement is made *ἕκαστον γὰρ τρύπημα τῶν αὐλῶν τρεῖς φθόγγους, ὥς φασιν, τοὐλάχιστον ἀφίησιν. εἰ δὲ καὶ τὰ παρατρυπήματα ἀνοιχθείη, πλείους.* A second hole in the band, such as has been described, might well be called a *παρατρύπημα* and would double the number of notes that could be produced on the instrument. With such a double arrangement and with tubes of proper length, a difference of half a tone in pitch could be produced by employing alternately the tube and the hole. Unfortunately, the word *παρατρύπημα* is found in no other place in Greek literature, so that any attempt to explain its meaning is purely conjectural, and while the explanation given above satisfies all the requirements of the passage in Proclus, I offer it simply as a suggestion.

ΚΟΙΛΙΑΙ.

As regards the *κοιλίαι*, which are mentioned by Aristoxenus (Harm. p. 60, ed. Marquard) as a part of the *αὐλός*, probably the main bore of the instrument is meant. There is nothing against this view except the use of the plural in this passage of Aristoxenus, while the following passages from ancient writers favor such an explanation.

Porphyrius ad Ptol. p. 217, ed. Wallis: πάλιν δὲ ἐὰν λάβῃς δύο αὐλοὺς, τοῖς μὲν μήκεσιν ἴσους· ταῖς δὲ εὐρύτησι τῶν κοιλιῶν διαφέροντας· καθάπερ ἔχουσιν οἱ Φρύγιοι πρὸς τοὺς Ἑλληνικοὺς· εὑρήσεις παραπλησίως τὸ εὐρυκοίλιον ὀξύτερον προιέμενον φθόγγον τοῦ στενοκοιλίου· θεωροῦμεν γέ τοι τοὺς Φρυγίους στένους ταῖς κοιλίαις ὄντας ἐπὶ πολλῷ βαρυτέρους ἤχους προβάλλοντας τῶν Ἑλληνικῶν. Here the κοιλίαι can hardly be anything else than the bore of the instruments, and the same is true of Nicomachus, p. 9, ed. Meibom: ἀνάπαλιν γέ, τῶν ἐμπνευστῶν αἱ μείζονες κοιλιώσεις, καὶ τὰ μείζονα μήκη, νωθρὸν καὶ ἔκλυτον. Furthermore, the word *cauernae* is used in Latin with the same meaning, Servius ad Aen. IX. 615: tibiae aut Serranae dicuntur, quae sunt pares et aequales habent *cauernas;* aut Phrygiae, quae et impares sunt et inaequales habent *cauernas.*

KINDS OF PIPES.

A long list of names of αὐλοί has been preserved in Pollux IV. 74 sqq. and in Athenaeus IV. 76 sqq., and from these lists it is apparent that the number of different varieties of this instrument was very great. In some cases, however, two or more names for the same variety of instrument have been preserved, as can be clearly shown, and this is probably true in many cases where proof is impossible. In the following pages an attempt has been made to distinguish, so far as possible, between the different kinds of instruments with reference to the manner in which the tone was produced on them, and then to classify the instruments themselves with reference to the pitch of their tones.

SINGLE PIPES.

The performer either made use of a single pipe, or he played upon two pipes at the same time. Several names of single pipes have been preserved, although perhaps not one of them is a name which was intended to distinguish the entire class of single pipes from the class of double pipes. The word μόναυλος seems to have as its first element the adjective μόνος, and unquestionably Martial had this view when he wrote XIV. 64: —

> Ebria nos madidis rumpit tibicina buccis:
> Saepe duas pariter saepe monaulon habet."

It is apparent, however, from a passage in Pliny N. H. VII. 204, that not all single pipes belonged in the class of *μόναυλοι*. His words are: musicam Amphion (inuenit) fistulam et monaulum Pan Mercuri, obliquam tibiam Midas in Phrygia, geminas tibias Marsyas in eadem gente. The *tibia obliqua* was undoubtedly a single instrument, but it is not classed by Pliny among the *μόναυλοι*. This same distinction between the *μόναυλος* and the *πλαγίαυλος* is made by Juba as quoted by Athenaeus IV. 78, and it is possibly from Juba that Pliny's statement is drawn. Pollux, IV. 75, distinctly states that the *μόναυλος* is of Egyptian origin: *μόναυλος εὕρημα μέν ἐστιν Αἰγυπτίων*,[1] and since among the Egyptians the word *ma-it*[2] was the general name for αὐλός, which was, however, used in a restricted sense to indicate an instrument held like the clarinet or oboe, as distinguished from one held as the flute is held, von Jan, Baumeister's Denkmäler, p. 562, is of the opinion that the *μον-* of *μόναυλος* is derived from the stem *mam* or *mom* of this Egyptian word, and that it has no connection with the Greek word *μόνος*.

There is no etymological reason whatever for assuming that this word is not composed of *μόνος* and *αὐλός*, exactly as it seems to be; and, furthermore, the *μόναυλος* was, as is implied in this derivation, always a single pipe.

From the fact that the *μόναυλος* is thus contrasted with the *πλαγίαυλος*, it would appear that the *μόναυλος* was a single pipe blown at the end.

The single pipe is very rarely represented in Greek and Roman works of art; in nearly every statue in which it is represented the instrument has been arbitrarily restored, and in very many instances it is absolutely impossible to prove that the hand originally held a pipe of any sort.[3] In reliefs and paintings where the instrument is not a restoration two classes of *αὐλοί* can be distinguished, one held horizontally like the modern flute, and the other held in front of the performer like a clarinet or oboe. If the name μόναυλος has been correctly interpreted in the preceding paragraph, it would naturally apply only to the second class of instruments named above; but as instruments of this class seem to have the same general characteristics as the double pipe, they will be treated in connection with the double pipes.

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[1] Cf. Athenaeus IV. 78.

[2] Cf. Loret, p. 126.

[3] The single pipe blown at the end like a clarinet is represented on a sarcophagus in the Louvre, Fröhner, No. 240, and in the following wall-paintings, Helbig, Wandgemälde Nos. 227, 767, and possibly it is not a restoration in a statue of Euterpe in the Naples Museum (no No.). All of these representations I have seen, as also the following in which the instrument has been restored; Louvre, Fröhner, Nos. 287, 382, 395; Rome, Cap. Mus., Helbig's Führer, Nos. 430(12), 521(10); Vatican, Helbig, No. 209(406); Munich, Glyptothek, Nos. 105, 106; Berlin, Antiken Skulpturen, 258, 259, 602.

Instruments of the first class were probably designated as a rule by the name πλαγίαυλος, Latin *tibia obliqua,* although there were undoubtedly separate names for the different varieties of instruments of the class.

The πλαγίαυλος is frequently mentioned by Greek and Roman writers. According to Pollux[1] IV. 74, it was invented by the Libyans, and was made of lotus wood; according to Pliny, VII. 204, it was invented by Midas in Phrygia. A passage in Apuleius, Met. XI. 9, shows that the instrument was held horizontally, exactly as the modern flute is held: *calamus obliquus ad aurem porrectus dexteram,* a fact which might have been inferred from the adjectives πλάγιος and *obliquus* which are used to describe it.

Instruments of the πλαγίαυλος-type are extremely rare in works of art, and, wherever they are represented, the entire instrument is, with very few exceptions, a restoration, and therefore of no value in determining the actual appearance of the ancient instrument.[2] Works of art in which there has been no restoration show at least two, and probably three, varieties of the instrument. A wall-painting from Pompeii[3] and a little gold ornament[4] from a tomb in Russia represent musicians performing on an instrument held horizontally in front of the mouth of the performer exactly as the modern flute is held. The instrument in the painting is a straight tube with flaring ends, that in the little ornament is a simple bar of gold, bent, at present, at the end farthest from the mouth, although, as we are informed in the account of it, the bar was probably originally straight. Neither of these instruments shows holes either for the fingers or for the mouth, but the fingers, in both cases, rest on the tube as though they were intended to cover holes in it. In modern instruments of this character the end nearest the mouth-piece is stopped with a cork, and this was probably true of the ancient instrument, in which case it would correspond exactly with the modern flute; but as no instrument of this character dating from ancient times has yet been discovered, it is, of course, impossible to decide this point except by inference.

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[1] Cf. Athenaeus IV. 78.

[2] The πλαγίαυλος is represented on two reliefs in the Louvre, Fröhner, Nos. 88, 373, and in the hands of a little terra-cotta figure, cf. Heuzey, Les figurines, etc., pl. 136; also in a wall-painting, Helbig, Wandgemälde, No. 760. It has been partially restored on a sarcophagus in the Vatican, cf. Mus. Pio Clem. V. 13, and on a Herma of the British Mus., cf. Anc. Marb. II. 36, but in both of these cases enough of the instrument is preserved to make the restoration certain. All of these representations I have seen except the one in the B. M., and of that I have seen a cast. I give also a few of the restorations: Louvre, Fröhner, Nos. 262, 263; Berlin, Ant. Skulpturen, Nos. 260, 261; Rome, Vatican, Helbig's Führer, No. 19 (36 A).

[3] Helbig, Wandgemälde, No. 760, Zahn III. 31, Mus. Bor. XV. 18.

[4] Compte Rendu, 1867, p. 45, atlas, pl. 6.

A second form of this instrument is represented in a relief on a *puteal*[1] in the Louvre, and by a terra-cotta figure,[2] also in the Louvre. In both of these representations the performer is blowing, not across a hole in the side of his instrument, but across the open end of the tube. The tube is held horizontally, or nearly so, and the hands occupy the same position as on the modern flute, although in neither of these instruments is there any trace of finger-holes. One might be tempted to think that the artist, from carelessness or ignorance, had represented inaccurately the manner in which the instrument was held, were it not for the fact that on Egyptian monuments the transverse pipe is always[3] represented as being held in this way. The πλαγίαυλος, as we are informed by Pollux and Athenaeus (cf. page 14), was invented by the Libyans, and if this statement is true, there is sufficient reason for believing that these two works of art represent accurately the way in which the pipe was sometimes held. The Arabs of to-day perform in the manner described[4] on a simple pipe of reed provided with finger-holes and open at both ends, and by careful experiment the reader can convince himself that it is possible in this way to produce not only the fundamental tones of a pipe, but also the harmonics.[1] Instruments belonging to either of these varieties would have the acoustic properties of the open pipe, and with six finger-holes would give the complete diatonic scale through at least two octaves: they might properly be called flutes.

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[1] Fröhner, No. 88; cf. Clarac, pl. 130, 139, n. 141.

[2] Heuzey, Les figurines, etc., p. 136.

[3] Loret, p. 209. La flûte oblique était un simple tube ouvert aux deux bouts, dans lequel on soufflait en biais. Jamais, en effet, on n'a trouvé de flûte munie d'une ouverture latérale semblable à celle par laquelle on souffle dans nos flûtes modernes; jamais non plus, dans les bas-reliefs, la flûte oblique n'est représentée dépassant légèrement la bouche de l'instrumentiste.

[4] Loret, p. 219.

What has been described as probably a third form of the *πλαγίαυλος* differs from the other two varieties in that it has a mouth-piece inserted, not into the end, but into a hole in the side of the instrument near the upper end, which is closed. Instruments of this type are represented on a sarcophagus[2] in the Vatican and by a Herma[3] in the British Museum, and although in the second of these representations the instrument, with the exception of the mouth-piece, is a restoration, there can be no doubt that the instrument has been properly restored. In both of these cases the mouth-piece consists apparently of a short tube, and was perhaps a reed, like the reed of an oboe or of a clarinet, for in the Herma, which I have seen only in a cast, the mouth-piece seems to have been held between the lips. There seems to be authority for such an inference in Aristotle[4] de audib. p. 801 b, *δῆλον δέ ἐστι κἀπὶ τῶν αὐλῶν· τὰ γὰρ ἔχοντα τῶν δευτέρων τὰς γλώσσας πλαγίας, μαλακοτέραν μὲν ἀποδίδωσι τὴν φωνὴν, οὐχ ὁμοίως δὲ λαμπράν*, where *γλῶσσαι πλάγιαι* could very well refer to a mouth-piece extending obliquely from the instrument in the manner described above.

There are, further, in the British Museum[5] two instruments which were possibly intended to be used as a pair, although in their present form it would be impossible to play on them both at once. One of these pipes is closed at the upper end, and although the corresponding end of the second pipe is now broken, it was undoubtedly originally closed as in the first instrument. Near this closed end there is on each pipe the raised bust of a Maenad, above the forehead of which a hole is bored obliquely into the main tube, the slant of the hole being toward the lower open end of the instrument. One of these pipes has six finger-holes, the other five, and there are lines around the pipes between the finger-holes which indicate the points of meeting of bands such as were found on the Pompeian instruments. The hole above the head of the Maenad is evidently intended for the reception of the mouth-piece; the fact that it is bored obliquely clearly shows that it was not itself the mouth-piece, but that the latter was inserted into it. The arrangement of bands and finger-holes differs slightly in these two instruments, so that the scale of both cannot have been exactly the same; but the resemblance between them in size and in appearance seems to indicate that, in spite of the slight difference in scale, they were used as a pair. The presence of bands on instruments with so few finger-holes is a further indication that they formed a pair, for on a single pipe the fingers of both hands could be used to close the holes, and on such an instrument, with but six holes, the bands would be an encumbrance rather than a help, unless, as is hardly conceivable, they were immovable and were intended merely as a kind of ornament.

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[1] This is by no means an easy operation, and Loret, p. 219, says that his experiments were entirely unsuccessful. It was only after many failures that I succeeded in producing clear tones. The instrument used was a joint of bamboo with an internal diameter of 1 cm. and a length of about 30 cm.

[2] Mus. Pio Clem. V. 13.

[3] Anc. Marb. II. 36.

[4] Quoted by Porphyrius ad Ptol., p. 249.

[5] Cat. Nos. 84, 4-9, 5 and 6.

Without some additional form of mouth-piece the two instruments cannot have formed a pair, since it would be impossible to perform on both of them at once in their present state. It would, of course, be possible to insert into each of these pipes such an S-shaped tube as is used on the bassoon of the modern orchestra, and thus to perform on both of the instruments at the same time, but there is nothing in the literature or in the works of art to indicate that mouth-pieces of this description were ever used with pairs of pipes. On the other hand, the two works of art which have been mentioned do show a form of πλαγίαυλος with a mouth-piece inserted into the side of the tube; and, in the absence of any evidence showing that a similar form of mouth-piece was ever used on the double pipe, I am inclined to think that these instruments from the British Museum were used as single pipes, and belong to the type of πλαγίαυλος shown in these two works of art.

By far the greater number of representations of the αὐλός show the performer blowing directly into the end of the pipe or pipes, which are held in front of him, pointing downward like the clarinet or oboe; and, with very few exceptions, the works of art show pairs of pipes and not the single instrument.

The single pipe is, however, represented in works of art and is mentioned in the literature, so that it would be impossible to deny the existence of such an instrument. In works of art it is represented as a straight tube, and in the Pompeian wall-painting, Helbig, 767, it is provided with a bell like the bell of the modern clarinet or oboe. The mouth-piece, of which a fuller description will be given later, has occasionally the appearance of an oboe-reed.[1] The single pipe was undoubtedly in most cases a reed-instrument, and was then constructed exactly like one of the pipes of a pair, but there is occasional mention of a single pipe which may possibly not have been a reed-instrument.

The reasons for believing that such an instrument existed are as follows: Athenaeus, IV. 82, in speaking of the inventors of the various musical instruments, says: Μητρόδωρος δ' ὁ Χῖος ἐν Τρωικοῖς σύριγγα μέν φησιν εὑρεῖν Μαρσύαν καὶ αὐλὸν ἐν Κελαιναῖς, τῶν πρότερον ἑνὶ καλάμῳ συριζόντων. Εὐφορίων δ' ὁ ἐποποιὸς ἐν τῷ περὶ μελοποιῶν τὴν μὲν μονοκάλαμον σύριγγα Ἑρμῆν εὑρεῖν, τινὰς δ' ἱστορεῖν Σεύθην καὶ Ῥωνάκην τοὺς Μήδους, τὴν δὲ πολυκάλαμον Σειληνὸν, Μαρσύαν δὲ τὴν κηρόδετον.[2] A distinction is here made between the σῦριγξ μονοκάλαμος and the σῦριγξ πολυκάλαμος, and the fact that the name σῦριγξ is used for both clearly points to some resemblance between them. The σῦριγξ πολυκάλαμος is the ordinary pan's-pipe, in using which the performer simply blew across the open ends of the tubes, which were held vertically in front of the mouth. The tubes of the pan's-pipe were ordinarily simple joints of reed, and it is clear from a passage in Porphyrius (ed. Wallis, p. 237) that they were not always closed at the bottom,[3] and that when they were not closed, two different tones could be produced on each tube, one when the tube was open at both ends, and the second when the lower end was stopped by the finger of the performer. It is but a step from such an instrument as this to a single tube open at both ends and provided with finger-holes, and the new instrument could appropriately be called a σῦριγξ μονοκάλαμος. The σῦριγξ, mentioned near the beginning of Aristotle's problem XIX. 23 (quoted on p. 3), was probably a σῦριγξ μονοκάλαμος. How many finger-holes this instrument had is not stated; it certainly had one in the middle of the tube, and the note produced when this hole was open was an octave above the note produced when it was closed.[1] That such an instrument belongs among the αὐλοί has been seen in the case of the πλαγίαυλος, and furthermore Pollux, IV. 69, twice calls the tubes of the pan's-pipe αὐλοί. It is possible on such an instrument, provided with six finger-holes, to produce a continuous scale through two octaves; the instrument having the acoustic properties of the open pipe. The scholion to Pindar, Pyth. XII. 1, favors this explanation, and the wonderful accomplishment of Midas of Agrigentum can be easily explained; for, after the reeds of the pipes were broken, he blew on the pipes alone τρόπῳ σύριγγος, simply holding them vertically before his mouth and blowing across the open ends of them. The difficulty would consist simply in the necessity of blowing on both of them at once.[2]

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[1] Mus. Borb. XVI. 3, cf. Baumeister, fig. 595.

[2] Perhaps Plin. N. H. VII. 204 was copied from this same source, fistulam et monaulum Pan Mercuri (inuenit), and we should read fistulam monaulum = σῦριγξ μονοκάλαμος.

[3] In the Museum für Völkerkunde in Berlin, I remember having seen, in the collection from Bolivia, a pan's-pipe in which the tubes were open at both ends.

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[1] This instrument cannot be the same as the σῦριγξ mentioned later in this same passage of Aristotle, and in which the tubes were either stopped at the end or partially filled with wax, for if such an instrument had a hole in the middle of one of its tubes, the note when the hole was open would be not one but two octaves above the note produced with the hole closed. With the hole closed the instrument is a stopped pipe, but with the hole open it is an open pipe, one half as long as the original stopped pipe, and would therefore give as its note the double octave.

The use of the same word σῦριγξ with two different meanings within so short a space can be easily explained. In illustrating the ratio of the note to its octave (2 : 1), the writer began with the string of a musical instrument which, if plucked so as to resound through half its length, gives the octave of the note produced by the whole string. Applying this same principle to the other instruments he shows that on the σῦριγξ μονοκάλαμος the octave is produced by boring a hole in the middle of the tube, and in the same way also in the αὐλός; but in the σῦριγξ πολυκάλαμος, in which the tubes are stopped pipes without finger-holes, the octave is produced by filling the tube half full of wax.

[2] Gevaert, Hist. de la Musique, II. p. 275, explains the σῦριγξ μονοκάλαμος as an instrument with a flageolet mouth-piece like that of the ordinary whistle, and says that these instruments occur no less frequently in works of art than does the pan's-pipe. I cannot, however, admit that this proves the existence of a flageolet in ancient times; for after a careful examination of all such instruments which I could find in Naples, Rome, and Paris, I am thoroughly convinced that in every case the instrument is a restoration and of no value in determining this question.

The *σῦριγξ μονοκάλαμος* was also called Ἶυγξ (cf. *Etym. Mag. s.v.* Ἶυγξ, *Bekker, Anecdota Graeca*, I. 265), and if it received this name from the fact that its note resembled the note of the bird, it must have been a pipe of high pitch.

DOUBLE PIPES.

Egyptian reliefs and paintings, even the oldest of them, most frequently show performances on the double pipe. Assyrian[1] reliefs, with no exception, show the double pipe, and with very few exceptions the same is true of Greek and Roman works of art. These Greek and Roman representations are very numerous. Especially is this true of vase-paintings, of which several hundred could easily be catalogued; and yet in nearly every instance the double pipe is shown. In the literature the mention of the double pipe is equally predominant; the words *αὐλοί* and *tibiae* are regularly used in the plural. The natural inference from this evidence is that the musician usually performed on a pair of pipes.

Gevaert, Histoire de la musique, Vol. II., p. 285, asserts that the great artists, Olympos, Sacadas, and Pronomos, played only on the single pipe and that this was the instrument used by the virtuosi at the Delphic contests. The evidence tending directly to disprove both of these statements is, however, of the most convincing character. In the scholia to Pindar, Pyth. XII. 1, we are told that Midas of Agrigentum, who won the prize at two Delphic contests, once had the misfortune, in the midst of a contest, to break the mouth-pieces of his instruments, but that he continued his performance *μόνοις τοῖς καλάμοις τρόπῳ σύριγγος* and won the contest. It is to be noticed that this contest took place at Delphi, and that the pipes are mentioned in the plural. In the 48th Olympic[2] contest Sacadas the Argive won *ἐπὶ τοῖς αὐλοῖς*, where again the plural is used. Pausanias

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This is distinctly the case in Paris, where the restorations are conscientiously stated in the catalogues, and in Naples and Rome every such instrument is either restored or broken. It is interesting to note that in Wilkinson's *Manners and Customs of the Egyptians*, Vol. II. pl. 183, there is represented from a relief in Thebes, a musician performing this very feat attributed to Midas. I cannot, however, vouch for the trustworthiness of this representation, not having seen the original.

[1] Rawlinson, Ancient Monarchies, Vol. I., p. 533.

[2] Pausanias, X. 7. 4.

also describes a statue of Sacadas[1] holding pipes (again the plural) which were fully as long as the body of the musician. As for Pronomus, the passage from Pausanias which has already been quoted (p. 6) shows conclusively that he, too, used the double pipe, and the fact is further attested by Athenaeus, XIV. 31, διόπερ ἦσαν ἴδιοι καθ᾽ ἑκάστην ἁρμονίαν αὐλοὶ καὶ ἑκάστοις αὐλητῶν ὑπῆρχον αὐλοὶ ἑκάστῃ ἁρμονίᾳ πρόσφοροι ἐν τοῖς ἀγῶσι. Πρόνομος δ᾽ ὁ Θηβαῖος πρῶτος ηὔλησεν ἀπὸ τῶν αὐτῶν [αὐλῶν] πάσας ἁρμονίας. The following passage from Lucian implies that the musicians Timotheus and Ismenias also made use of the double pipe (adv. Ind. 5) εἴ τις αὐλεῖν μὴ ἐπιστάμενος κτήσαιτο τοὺς Τιμοθέου αὐλοὺς ἢ τοὺς Ἰσμηνίου, οὓς ἑπτὰ ταλάντων ὁ Ἰσμήνιας ἐν Κορίνθῳ ἐπρίατο, ἀρ᾽ ἂν διὰ τοῦτο καὶ αὐλεῖν δύναιτο; Even the vase-paintings[2] in which the musician is represented wearing a wreath, evidently as a token of victory, show him performing on a pair of pipes and not on the single pipe. There is no lack of further evidence on this point, but enough has already been said to show conclusively that the double pipe was used at the various musical contests and by the chief musicians of antiquity.

REEDS.

In the overwhelming majority of cases, the αὐλός must have been a reed-instrument. Aeschines[3] says distinctly that if the reeds (γλῶτται) of the pipes are taken away, what remains is useless. Aristotle[4] describes the eggs of the skate and of the dog-fish by saying that they resemble the γλῶτται of pipes, mentioning, of course, something perfectly familiar to his readers. Theophrastus,[5] in describing the κάλαμος αὐλητικός, assumes that the γλῶτται are a regular feature of the pipe. The word ἐξηυλημένος[6] in its colloquial meaning, "worthless," "played out," acquires this meaning from the fact that the worn-out reeds of pipes were thus designated.

Two types of reed-instruments are known to modern times, — the clarinet-type with a tube of cylindrical bore, and the oboe-type with a tube of conical bore. The mouth-piece of the clarinet has a rectangular opening in the side, over which a thin wedge of reed is bound in such a manner as to leave the thinner end free, so that when caused to vibrate by the breath of the performer it alternately closes and opens the aperture in the mouth-piece.

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[1] Pausanias, IX. 30. 2.

[2] Mon. dell' Inst. V. 10.

[3] Aesch. contra Ctes. 229, Bekker.

[4] Aristot. Hist. an. p. 565 a 22.

[5] Theophrastus, Hist. Plant. IV. 11.

[6] Aristophanes, Achar. 681, schol.; cf. Etym. Mag., s.v. ἐξηυλημένος.

The mouth-piece of the oboe is composed of two thin strips of reed which are bound firmly around a small conical tube, so that the ends of the strips project beyond the smaller end of the tube and flatten against each other, thus forming the apex of the cone. A reed of the oboe-type can be easily made of straw by splitting the straw for a short distance, and pressing the two halves together at the end.

There is a marked difference between instruments of these two types, those of the oboe-type having the acoustic properties of the open pipe, while those of the clarinet-type have the acoustic properties of the stopped pipe. This difference is caused by the bore of the instrument, and not by the form of mouth-piece employed; for the instrument invented by Adolph Sax, and known as the Saxophone, which is of conical bore and on which the tone is produced by means of a clarinet mouth-piece, has the acoustic properties of the open pipe, and the experiments with pipes of cylindrical bore described later in this article show that with either form of mouth-piece the cylindrical tube has the acoustic properties of the stopped pipe.[1] All Greek and Roman instruments, and all fragments of such instruments which have as yet been found, are of cylindrical bore, and have, therefore, assuming that they are reed-instruments, the acoustic properties of stopped pipes. Furthermore the statement of Aristotle as to the position of the finger-holes of the αὐλός (cf. p. 3 sq.) applies only to pipes of cylindrical bore.

In works of art the pipes are occasionally so represented that it seems absolutely necessary to assume that the bore must have been conical, and this is especially apparent in a relief of which a photographic reproduction is shown in the Bulletino Communale, 1880, Pl. VII.–VIII. Until, however, some instrument or fragment of an instrument is discovered which settles this question in the affirmative, it is only possible to say that the ancients may have had instruments of conical bore. Even the pipes found in Egypt must be regarded as cylindrical tubes, for they have only the natural taper of the material (reed) out of which they are constructed, and this is very insignificant.

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[1] Friedrich Zamminer, Die Musik und die musikalischen Instrumente, Giessen, 1855, p. 305, confirms this statement.

It does not, however, follow that the mouth-piece was always a clarinet mouth-piece, as has been assumed in all of the experiments hitherto conducted with pipes made in imitation of those found at Pompeii, and as is implied by von Jan[1] in his description of the αὐλός; in fact, there is fully as much evidence in favor of the oboe mouth-piece as there is in favor of the clarinet mouth-piece.

The split straw is the simplest possible form of oboe mouth-piece, and was certainly used as a reed by the ancient Egyptians. Loret (p. 207) says that in the case in which were found all of the Egyptian pipes now in the museum at Leyden was found also a number of short pieces of straw, and on p. 209 that two pipes, one in the British Museum and one in the museum at Turin, still have such a piece of straw inserted into the end as a mouth-piece.[2] The straw is in each case inserted into the smaller end of the pipe, although in neither case is the difference in diameter of the two ends more than one millimeter.

Vergil[3] and Tibullus[4] several times speak of the performer on the *auena*, or oat-straw, and, in view of this evidence from Egypt, it must not be rashly assumed that they are speaking figuratively. A reed of such simple construction may very well have been used by the shepherds on their pipes.

Theophrastus, Hist. Plant. IV. 11, describes at length the plant κάλαμος, from which the pipe and its mouth-piece were made, but unfortunately he does not tell exactly how the mouth-piece was made. After having been properly seasoned, the κάλαμος was cut into pieces corresponding to the joints of the plant, and on each piece the joint nearest the top was left. These pieces were not less than two palms in length, and the pieces from the middle of the stalk were considered the best for the mouth-pieces, ζεύγη. The mouth-pieces for both of the pipes of a pair were made from the same joint, for if not so made the reeds, we are told, would not sound in harmony. These joints were next cut in two, and the portion toward the root was used as the mouth-piece for the left-hand pipe, the other for the right-hand pipe; the *στόμα* (doubtless the end taken into the mouth) was in each mouth-piece at the point where the joint had been cut apart, and here, again, if this course was not followed, the reeds would not sound in harmony. Further than this Theophrastus does not go in describing how the mouth-piece was made, and whatever more is to be learned about these mouth-pieces must be learned by experiment. One of the pieces, as left by the description, is a simple tube of cane, open at both ends and about a palm in length; the other piece is of the same length, but stopped at one end by the joint of the cane. This stopped end is, however, to be inserted into the instrument, and consequently a hole must be bored through the joint to allow the air to pass through it. It is then possible either to split the tube and, after scraping the ends to be held in the mouth until they are very thin, to bind the two pieces together so as to make a reed like that of the modern bassoon, which is an instrument of the oboe-type; or by stopping the end to be taken into the mouth, making a rectangular opening in the side of the tube near this end, and binding over it a reed, as in the clarinet mouth-piece, to produce an instrument of the clarinet-type. The first of these methods is the simpler, and it is exactly in this way that the reed of the bassoon is made. Such a mouth-piece would, furthermore, be the most natural development from the primitive mouth-piece of straw. Too much stress must not be laid upon works of art, but in some of these the mouth-piece is so represented that one is almost compelled to believe that the artist had in mind this form of reed. This is especially true of a vase painting reproduced in the Mon. dell' Inst. XI. 27, and of the single pipe in the Pompeian wall-painting, Zahn, III. 43, to which reference has already been made. There is, moreover, nothing in the passage from Theophrastus inconsistent with this view, and one or two expressions used by this author in stating the best time for harvesting the *κάλαμος* are best explained by assuming that the reeds were of the oboe-type. These expressions are found in the following passage, which for the sake of clearness is given in full: Hist. Plant. IV. 11. 4, *τὴν δὲ τομὴν ὡραίαν εἶναι πρὸ Ἀντιγενίδου μὲν ἡνίκ᾽ ηὔλουν ἀπλάστως ὑπ᾽ ἄρκτουρον Βοηδρομιῶνος μηνός· τὸν γὰρ οὕτω τμηθέντα συχνοῖς μὲν ἔτεσιν ὕστερον γίνεσθαι χρήσιμον καὶ προκαταυλήσεως δεῖσθαι πολλῆς συμμύειν δὲ τὸ* στόμα τῶν γλωττῶν, ὃ πρὸς τὴν διατορίαν εἶναι χρήσιμον. ἐπεὶ δὲ εἰς τὴν πλάσιν μετέβησαν καὶ ἡ τομὴ μετεκινήθη· τέμνουσι γὰρ δὴ νῦν τοῦ Σκιρροφοριῶνος καὶ Ἑκατομβαιῶνος ὥσπερ πρὸ τροπῶν μικρὸν ἢ ὑπὸ τρόπας, γίνεσθαι δέ φασι τριενόν τε χρήσιμον καὶ καταυλήσεως βραχείας δεῖσθαι καὶ κατασπάσματα τὰς γλώττας ἴσχειν· τοῦτο δὲ ἀναγκαῖον τοῖς μετὰ πλάσματος αὐλοῦσι. Pliny, N. H. XVI. 171, who attempts to translate this passage, translates συμμύειν δὲ τὸ στόμα, etc., *comprimentibus se lingulis*, and κατασπάσματα τὰς γλώττας ἴσχειν, *apertioribus earum lingulis ad sonos flectendos.* It is difficult to see what these words can mean if applied to the mouth-piece of a clarinet, but if applied to that of the oboe they might mean that when the tube was split to make the reed, if the material had been cut at the proper season of the year, the two halves of the reed, when flattened against each other by pressure, retained this shape and did not have a tendency to curl up into their original form, — a tendency which is expressed in Pliny by the words *apertioribus earum lingulis ad sonos flectendos*, since if the reeds curled they would separate in the middle. Even the name ζεῦγος as applied to the mouth-piece seems to imply reeds of the oboe-type. This word naturally means a pair of like things and would here mean, when used in the singular, a pair of similar reeds united into a mouth-piece. The plural ζεύγη would then mean the two mouth-pieces of a pair of pipes. It is not easy to see what ζεῦγος could mean if applied to a clarinet mouth-piece. It is further to be noted that the clarinet has but one reed, while here Theophrastus uses the plural, τὸ στόμα τῶν γλωττῶν.

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[1] Baumeister, Denkm., p. 553; cf. Gevaert, II. p. 282.

[2] Cf. Wilkinson, Ancient Egyptians, Vol. II., p. 308.

[3] Vergil, Ecl. I. 2, X. 51, and the spurious lines at the beginning of the Aeneid.

[4] Tibullus, II. 1. 53, III. 4. 71.

Since the discovery of four ancient instruments at Pompeii in 1867, experiments with tubes made in imitation of them have been conducted by Kraus in Florence and by Gevaert in Brussels, with a view to determining the scales of these instruments. These experiments seem, however, to have been made in every instance on the assumption that with instruments of cylindrical bore it was necessary to make use of the clarinet mouth-piece.[1] The exact form of mouth-piece used in the experiments at Brussels and Florence on the facsimiles of Pompeian pipes, is described at length by von Jan in

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[1] Baumeister, Denkm., p. 553; Gevaert, Hist. de la musique, II. 280. The clarinet type of mouth-piece is used to-day by the Arabs (cf. Baumeister, p. 554; Loret, p. 234 sq.), who perform on an instrument corresponding in many respects to the double-pipe of antiquity, and it is possibly a survival of a very ancient usage.

Baumeister's Denkmäler, p. 554. This form of mouth-piece certainly does give a fuller and clearer tone than the reed of the oboe-type; but, as has already been stated, the form of mouth-piece has no effect on the harmonics of the pipe, and with the Pompeian instruments the scale is exactly the same, no matter which form of reed is used. The works of art give very insufficient material from which to decide this question, and it is, of course, possible that both forms of mouth-piece were used.

The reeds were taken directly into the mouth, and were not enclosed in an air-chamber, as is shown by the following passage from Aristotle[1] (de audib. p. 802 b, 18): δεῖ γὲ καὶ τῶν αὐλῶν εἶναι τὰς γλώττας πυκνὰς καὶ λείας καὶ ὁμαλάς, ὅπως ἂν καὶ τὸ πνεῦμα διαπορεύηται δι᾽ αὐτῶν λεῖον καὶ ὁμαλὸν καὶ μὴ διεσπασμένον. διὸ καὶ τὰ βεβρεγμένα τῶν ζευγῶν, καὶ τὰ πεπωκότα τὸ σίαλον, εὐφωνότερα γίγνεται· τὰ δὲ ξηρὰ κακόφωνα· ὁ γὰρ ἀὴρ διὰ ὑγροῦ καὶ λείου φέρεται μαλακὸς καὶ ὁμαλός. The following passages show further that the entire mouth-piece was not taken into the mouth so that the reed swung perfectly free in the mouth of the performer, but that the reed or reeds were held between the teeth or lips of the performer, so that he could use them to govern the tones produced on his instrument. Aristotle de audib. p. 804 a (cf. Porphyrius, p. 252) καὶ γὰρ ἂν πιέσῃ τις τὰ ζεύγη, μᾶλλον ὀξυτέρα ἡ φωνὴ γίγνεται καὶ λεπτοτέρα; Porphyrius, p. 249, ἐν δὲ ταῖς συγκροτέραις γλώσσαις, ἡ φωνὴ γίγνεται σκληροτέρα καὶ λαμπροτέρα, ἂν πιέσῃ τις αὐτὰς μᾶλλον τοῖς χείλεσι; and Festus (ed. Müller, p. 116) s.v. lingula — alias insertae, id est *intra dentes coercitae* ut in tibiis.

This control of the reeds exercised by the lips is one of the principal means for correcting the pitch of the pipe to which reference has already been made, and these passages show clearly that this device was well known to the ancient musicians.

The entire mouth-piece, including the reeds, seems, from the various passages quoted, to have been called the ζεῦγος; but as the important part of it was the reeds, the name γλῶττα was often used to designate the entire mouth-piece, as is shown by the use of this word and by the fact that the mouth-piece, which fitted into a socket in the end of the tube and which could be detached from the instrument, when not in use was kept in a little case called the γλωττοκομεῖον.[1] Such a case for mouth-pieces is shown in a number of vase-paintings,[2] and appears to have been simply a small bag.

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[1] Quoted also by Porphyrius, p. 250.

Where two pipes were employed at the same time, each had a separate mouth-piece, as is distinctly shown in every[3] work of art which has been preserved to our time. This statement is confirmed by the Egyptian and Assyrian works of art, for in them the instruments are never represented as uniting in a single mouth-piece.

In addition to this, experiments which I have made with pairs of pipes of various sizes united by a single mouth-piece, into which could be fitted reeds of both the types described above, made it very apparent that the pipes were not intended for use in this manner. With either form of reed the pipes cannot be made to sound independently, and they admit of the production of but one tone at a time. If the open end of either pipe is closed, a note an octave lower than before is produced, which would seem to indicate that such an instrument was acoustically an open pipe. The harmonics of the instrument, however, when both pipes are open, are those of the stopped pipe. That the pipes do influence each other is shown by the fact that, although with pipes of equal length the resultant note is the note which either pipe alone would give, with unequal pipes the resultant is not the fundamental note of either pipe but the average of the notes of both. I further observed that the angle which the two pipes made with each other had absolutely no influence on the pitch of the tone.

These experiments were made both with pipes of the same length and with pipes of different lengths, and the result was always the same. With pipes of unequal length the result is by no means surprising; for, theoretically, it seems impossible that a single reed should be able so to vibrate as to produce different tones on two pipes at the same time. In the light of these experiments, therefore, it is safe to say that the two pipes were never made to sound with the same reed, and that, if they were ever united by a single mouth-piece, the mouth-piece must be regarded simply as an air-chamber, within which each pipe had its own reed.

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[1] Pollux, II. 108, VII. 153, X. 153-4.

[2] Baumeister, Denkm., p. 554, Fig. 591.

[3] In Bartholinus, de tibiis veterum, pp. 51, 52, there are two engravings which represent pairs of pipes, each pair uniting in a single mouth-piece. The first is a reproduction from J. J. Boissard, Antiquitates Romanae, in which a sacrifice to Priapus is represented; the second is from J. P. Bellori, Admiranda Rom. antiq. vestigia, pl. 47, in which is shown a female figure playing on a pair of curved pipes. I have sought diligently for the original reliefs from which these engravings were made, but have never been able to find them, nor have I ever seen in an ancient work of art two curved pipes in the hands of a musician.

ΟΛΜΟΣ, ΥΦΟΛΜΙΟΝ.

There are two portions of the instrument, near the mouth-piece, for which names have been preserved, — the *ὅλμος*[1] and the *ὑφόλμιον*.[2] Two explanations of these parts of the instrument, neither of them entirely satisfactory, have been offered, — one by Gevaert, Vol. II., p. 285, in which the *ὅλμος* is described as the mouth-piece, the *ὑφόλμιον* as the upper part of the instrument, into which the *ὅλμος* was inserted; the other by von Jan, in the *Allgemeine musikalische Zeitung*, 1881, No. 31, in which the *ὅλμος* is described as the beak or mouth-piece of the clarinet-type, the *ὑφόλμιον* as the reed itself, which rested on the under lip of the performer, and was therefore under the *ὅλμος*. But there is absolutely no evidence that the *ὅλμος* was ever taken into the mouth of the performer, as would be required by either of these explanations, and a much simpler explanation than either of them is possible. The word *ὅλμος* signifies a mortar, or a peculiar shaped cup, and the word *ὑφόλμιον* signifies originally a support or stand for the *ὅλμος*; cf. Aristophanes, in Pollux, X. 114; Hesychius, s.v. The mortar and mortar-stand, as shown in a vase-painting,[3] have a very striking resemblance to the upper end of the instruments from Pompeii (Pl. II.), and it is not improbable that these parts of the pipes received their names on account of this resemblance. According to this view, the *ὅλμος* is the pear-shaped bulb, and the *ὑφόλμιον* the flaring tube inserted into it.[4] The bulb, or *ὅλμος*, is very frequently shown in works of art,[5] and it is interesting to note that on the modern clarinet this part of the instrument has, in all countries, received its name from its resemblance to some familiar object, being called in America and in England the 'pear,' in Germany 'die Birne,' in France 'le baril,' etc.

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[1] Pollux, IV. 70.

[2] Pollux, IV. 70; Hesych. s.v. *μέρος τι τοῦ αὐλοῦ πρὸς τῷ στόματι, ἦ αἱ γλωττίδες. καὶ ὑπόθεμά τι.* For ἥ Aug. Wagener reads ἢ. Ptol. Harm. I. 3, p. 7, ed. Wallis.

[3] Jahn, Bericht. der Sächs. Acad., 1867, taf. 1. 4; cf. Schreiber, Bilderatlas, taf. LXVII., Fig. 3.

[4] Von Jan, Baumeister's Denk., p. 556, suggests the possibility of some such explanation as is here offered.

[5] Both *ὅλμος* and *ὑφόλμιον* are shown in a Pompeian wall-painting (Helbig, Wandgemälde, No. 114), and in a mosaic in the Museo Kircheriano; for the *ὅλμος*, cf. Mon. dell' Inst. VI. 18; H. d'Escamps Marbres du Musée Campana, pl. 25; Baumeister, fig. 598; etc.

The part which has been called the ὑφόλμιον is not always shown as a flaring tube, but is often represented as a cylindrical tube. It is evident from the statement of Hesychius, μέρος τι τοῦ αὐλοῦ πρὸς τῷ στόματι, that the ὑφόλμιον was near the mouth-piece of the instrument; but it is equally clear from the catalogue of the various parts of the αὐλός as given by Pollux, IV. 70, that it cannot be identical with the reed, for both of these parts are mentioned, and in such a way as to imply that they were not identical.

According to this view, Gevaert is correct in assuming that the ὑφόλμιον was the flaring tube into which the mouth-piece was inserted, but is incorrect in assuming that the ὅλμος was the mouth-piece.

ΦΟΡΒΕΙΑ.

In performing on the double-pipe a great deal of pressure was exerted by the breath on the cheeks and lips, and to relieve this pressure the performer made use of a bandage, passing over the mouth and cheeks and provided with holes through which the mouth-pieces of the instruments could be passed. Such a bandage is frequently shown in works of art, and was called by the Romans *capistrum*, by the Greeks φορβεία, περιστόμιον.[1] It is only with reed-instruments that the *capistrum* can have been used for the purposes here stated; with any other type of instrument the pressure of the breath would be very slight and the bandage would be an inconvenience rather than a help.

It has occurred to me that possibly this bandage was intended to serve still another purpose; that of holding the instruments to the mouth of the performer so that the hands might be left free to move up and down on the instruments, as would be necessary in turning the bands, and in opening and closing the finger-holes. Inasmuch as but one hand could be employed for each pipe, some such arrangement was highly desirable if not absolutely necessary and especially if the number of finger-holes was very great.

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[1] Schol. Ar. Vesp. 580; Hesych., s.v.; Suidas, s.v.

A *capistrum* could easily be constructed in such a way that the mouth-pieces would fit tightly into it and support the instruments, leaving the hands absolutely free to move.

The instruments themselves, when not in use, were kept in a case called *συβήνη*.[1] Such cases are frequently shown in works of art, and regularly have a separate compartment for each tube. No Greek or Roman cases of this sort have ever been found, but two instrument-cases have been found in Egypt and are preserved, one in the Louvre at Paris, the other in Leyden (Loret, pp. 199 and 201).

HARMONICS.

There are very convincing proofs that the acoustic properties of the αὐλός were well known to the Greeks and Romans, and that they made use of the harmonic tones of their instruments in their music. In all vase-paintings and in many of their reliefs, the instruments are represented as tubes of small diameter in comparison with their length. The pipes represented in Egyptian works of art show this same peculiarity, and of the existing instruments described by Loret (p. 197 fg.) only one has a diameter so great as 1.8 cm. while with few exceptions the diameter is less than 0.6 cm. The four pipes found at Pompeii have an internal diameter of 0.95 cm. and the diameter of the Greek instruments in the British Museum is correspondingly small.

It seems clear, therefore, that these instruments were ordinarily of small diameter as compared with their length. Tubes of such dimensions facilitate the production of the harmonic series of tones (cf. Zamminer, die Musik und die mus. Instr., p. 218), and the ancients very probably had this object in view in constructing their instruments with these dimensions.

Aristoxenus[2] gives the range of a single pipe as two octaves and a fifth, *τὸ διὰ πέντε καὶ τὸ δὶς διὰ πασῶν*, and this range for the diatonic scale alone would, without the use of harmonics, require eighteen finger-holes. Not only is this a larger number of finger-holes than is found on any instrument preserved to our time, but the difficulties of performing on such an instrument would be very great, on account of the fact that the holes nearest the mouth-piece would be very close together. Furthermore, Proclus, in his commentary to Plato's Alcibiades, chap. 68, says that from each hole of the pipe at least three tones could be produced, and that if the παρατρυπήματα are opened, even more tones are possible. A possible explanation of the παρατρυπήματα has already been given (p. 11); the important statement is that three tones can be produced from each hole, which can hardly be anything else than a reference to the harmonic tones of the pipe.

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[1] Pollux, VII. 153, representations Mon. dell' Inst. XI. 27 et al.

[2] Aristoxenus, Harm., ed. Marquard, p. 28.

In view of all this evidence it is somewhat surprising to observe that Gevaert[1] and others are of the opinion that the ancients could not produce the harmonics on their instruments, and that even with the pipes found at Pompeii it would be impossible to produce more than one tone for each of the lateral holes. The inaccuracy of this statement can be shown by actual experiment; for with tubes made in exact imitation of the pipes from Pompeii, with the aid of either form of mouth-piece described above, I have produced three tones from each hole, as stated by Proclus.

The modern clarinet has a small hole near the mouth-piece, called the "speaker," which, when open, *facilitates* the production of the harmonics, but it is not absolutely essential to their production, as can be demonstrated by actual experiment. It is reasonably certain that such an arrangement also existed on the ancient instruments, as will appear later, but its absence would not be proof that the harmonics were not used by the ancients.

In three different passages[2] in Greek writers the statement is made that if the performer presses[3] the ζεύγη or the γλῶτται of the pipes, a sharper tone is produced; and, although we have two different names for the part of the instrument on which the pressure is to be exerted, the actual operation in all of these cases was undoubtedly the same. By pressing with the lips or teeth on the reed of a clarinet[1] or oboe near the base of the reed, it is possible to produce the higher harmonics of the instrument, and this is in all probability what is meant by the passages quoted above.

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[1] Gevaert, Hist. de la Musique, II. 285; von Jan, Baumeister, Denk., 556.

[2] Aristotle, de audib., p. 804 a; Porphyrius, ed. Wallis, p. 249; id. ib., p. 252.

[3] K. von Jan, in Philologus, XXXVIII., p. 382, interprets the words ἂν πιέσῃ τις τὰ ζεύγη as 'wahrscheinlich wenn man die Klappen öffnet.' In the other passages quoted it is, however, the γλῶτται which are operated upon, and in Porphyrius, p. 249, the words are ἂν πιέσῃ τις αὐτὰς μᾶλλον τοῖς χείλεσι, which cannot possibly refer to opening the keys of the instrument, but must refer to pressure with the lips upon the reeds. It is therefore to be assumed that where the ζεύγη are mentioned, the same operation is described as in the other two instances, and that the word ζεύγη is simply a more comprehensive term, meaning mouth-pieces including the reeds. Moreover, it does not seem possible that either of these expressions can mean opening the keys of the instrument, for the keys, if we call the bands by that name, were not opened by pressure.

Furthermore, with reedless instruments, such as the *σῦριγξ μονοκάλαμος* and the *πλαγίαυλος*, it seems impossible that the performer should not have discovered the existence of the harmonic tones; for on any instrument of this character a very slight additional effort to increase the power of the tone inevitably leads to the production of harmonic tones. It is, therefore, inconceivable that this phenomenon was not observed by the ancients.

THE SYRINX.

As has been said above, the modern clarinet has, near the mouthpiece, a small hole called the 'speaker,' which, when open, enables the performer to produce without effort the harmonic tones of the instrument. Although this device is not absolutely necessary, it is of the greatest assistance to the performer, especially in producing the first harmonics of the lowest tones.

There are a few passages in ancient writers which imply the existence of such an arrangement on the Greek and Roman instruments. Aristoxenus (ed. Marquard, p. 28) speaks of an attachment to the *αὐλός* which was called the *σῦριγξ*, and which, when in use, had the effect of raising the pitch of the instrument; his words are: *καὶ κατασπασθείσης γε τῆς σύριγγος ὁ τοῦ συρίττοντος ὀξύτατος πρὸς τὸν τοῦ αὐλοῦντος βαρύτατον μεῖζον ἂν ποιήσειε τοῦ ῥηθέντος διαστήματος*; that is to say, that when this attachment was in use the range of the pipes was more than two octaves and a fifth.

Aristotle (de audib., p. 804 a) mentions this same attachment, and ascribes to it the same effect on the tone of the instrument: *διὸ καὶ τῶν ἀνδρῶν εἰσὶ παχύτεραι καὶ τῶν τελείων αὐλῶν, καὶ μᾶλλον ὅταν πληρώσῃ τις αὐτοὺς τοῦ πνεύματος. φανερὸν δ' ἐστίν· καὶ γὰρ ἂν πιέσῃ τις τὰ ζεύγη, μᾶλλον ὀξυτέρα ἡ φωνὴ γίγνεται καὶ λεπτοτέρα. κἂν κατασπάσῃ τις τὰς σύριγγας, κἂν δὲ ἐπιλάβῃ, παμπλείων ὁ ὄγκος γίγνεται τῆς φωνῆς διὰ τὸ πλῆθος τοῦ πνεύματος καθάπερ καὶ ἀπὸ τῶν παχυτέρων χορδῶν.*

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[1] Cf. Zamminer, die Musik u. die mus. Instr., p. 301.

The effect produced by pressing with the lips on the reed, as has already been said, is to produce the harmonics of the pipe, and it is clear from this passage that the syrinx also served this purpose. Again, in Plutarch (non posse suav., p. 1096 a) the syrinx is mentioned as a part of the αὐλός: διὰ τί τῶν ἴσων αὐλῶν ὁ στενώτερος βαρύτερον φθέγγεται· καὶ διὰ τί τῆς σύριγγος ἀνασπωμένης, πᾶσιν ὀξύνεται τοῖς φθόγγοις, κλινομένης δὲ πάλιν βαρύνει καὶ συναχθεὶς πρὸς τὸν ἕτερον, διαχθεὶς δὲ ὀξύτερον ἠχεῖ. From this passage is derived the additional information that the syrinx affected all of the tones of the instrument, and although words of precisely opposite meanings, ἀνασπᾶν and κατασπᾶν, are used in these several passages to denote the method of employing the syrinx, the effect in all three cases was the same.

A little hole in the instrument, like the 'speaker' of the clarinet, would raise the tone of each hole to the harmonic 'overtones,' and such a hole could easily have been covered by a sliding band, which in some instruments was pushed up to open the hole, and in other cases pulled down for the same purpose, — a fact which would account for the difference in the use of the two words, ἀνασπᾶν and κατασπᾶν.[1]

In the Anecdota Graeca Oxoniensia, Vol. II., p. 409, several definitions of the word σῦριγξ are given, and one of them, σημαίνει τὴν ὀπὴν τῶν μουσικῶν αὐλῶν, shows that some hole of the αὐλός was actually called a syrinx.[2]

If the syrinx was such a device as has been described, light is thrown on a passage in Plutarch (de mus. 21), Αὐτίκα Τηλεφάνης ὁ Μεγαρικὸς οὕτως ἐπολέμησε ταῖς σύριγξιν, ὥστε τοὺς αὐλοποιοὺς οὐδ' ἐπιθεῖναι πώποτε εἴασεν ἐπὶ τοὺς αὐλούς, ἀλλὰ καὶ τοῦ Πυθικοῦ ἀγῶνος

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[1] The words ἀνασπᾶν and κατασπᾶν in these passages undoubtedly both mean 'to put the syrinx in operation,' although the manner of doing it is expressed by words of exactly opposite meaning. It seems impossible, therefore, that von Jan (Phil. XXXVIII., p. 382) should be right in thinking that a joint at the lower end of the instrument, which could be detached, was called the syrinx, and his explanation, 'Der Theil also, auf welchem man nach Abnahme der Syrinx weiter blasen kann, heisst selbst Syrinx und das Blasen darauf συρίττειν,' certainly does violence to the passage of Aristoxenus which he quotes. It is far more probable that the syrinx was itself a part of the instrument which could be put into operation by one or the other of the actions implied in the verbs ἀνασπᾶν or κατασπᾶν, and that συρίττειν means simply to perform on the instrument when the syrinx is in operation.

[2] Cf. Etym. Mag. s.v. σῦριγξ.

μάλιστα διὰ ταῦτ᾽ ἀπέστη. It would seem, then, that this musician considered the addition of the 'speaker' to his pipes as detracting from the dignity of his art, by making it possible for a poorer performer to produce, with ease, the harmonic tones, — an art which before this innovation required great skill on the part of the performer. The objections of this ancient artist to innovations can be paralleled by the objections of modern artists to the Boehm mechanism on the flute.

There is, further, a passage in Quintilian (I. 11. 6) which may possibly refer to this same syrinx: 'ne illas quidem circa s litteram delicias hic magister feret, nec uerba in faucibus patietur audiri nec oris inanitate resonare nec, quod minime sermoni puro conueniat, simplicem uocis naturam pleniore quodam sono circumliniri, quod Graeci καταπεπλασμένον dicunt; *sic appellatur cantus tibiarum, quae praeclusis, quibus clarescunt, foraminibus, recto modo exitu grauiorem spiritum reddunt.*' If the *foramina quibus clarescunt* can be interpreted to mean the 'speakers,' or holes by means of which the pitch is raised (*i.e.* the harmonics produced), this passage gives additional reason for believing that the ancients were acquainted with this device. The effect of closing the holes would be to lower the pitch of the instrument by causing the node in the instrument to disappear, so that the fundamental tones would be produced (*recto modo exitu grauiorem spiritum reddunt*).

The instruments found at Pompeii lend support to the theory that the 'speaker' was known to the ancients. Two of these instruments (Nos. 76891 and 76892, see Pl. II. figs. 1 and 2) have narrow bands of silver encircling the tube near the mouth-piece, and on one of the instruments the band is supplied with the mechanism to enable the performer to turn it round on the tube.[1]

The metal band of No. 76891 is badly oxidized, but even in the photographs of the instrument it is distinctly visible. The band of No. 76892 is very well preserved, and through it and into the tube of the instrument is a small hole, not larger than an ordinary sized pin. This hole is also visible in the photographs of the instrument; and even assuming that it is the result of accident rather than design, the fact that bands are found in this particular place on the instrument leads to the conclusion that there was a hole in the tube to be covered, and if so, what is more probable than that it was intended to be used as a 'speaker'?

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[1] In view of the fact that von Jan, in Baumeister's Denkmäler, p. 261, says that not the slightest indication of such a 'speaker' is to be seen on any of the remains of ancient instruments, it seems proper to state that only in the case of the instrument No. 76892 is there any indication of a hole in the tube. The band, however, exists on both of the instruments mentioned, and can be seen in the original photographs of these instruments in my possession. Further than this, I have personally examined the instruments themselves and have measured them. I also inserted a pin into the hole in this instrument and convinced myself that the hole actually extended into the main tube of the instrument.

KINDS OF DOUBLE PIPES.

In two passages[1] from Greek writers, which have already been quoted, the statement is made that, until the time of Pronomus, three different kinds of pipes were used for the three different scales, the Dorian, the Phrygian, and the Lydian, and that Pronomus improved the pipes so that all three of the scales could be played on the same pair of instruments.

This statement, however, must certainly not be interpreted as meaning that, from this time on, all instruments were of exactly the same length, for even after this improvement pipes of many different sizes were manufactured and used, as is shown by the statements of Greek and Roman writers, by the works of art, and by the instruments which have been preserved.

The Romans recognized two main classes of double pipes, which are thus described by Servius, ad Aen. IX. 615, 'tibiae aut Serranae dicuntur, quae sunt pares et aequales habent cauernas aut Phrygiae, quae et impares sunt et inaequales habent cauernas.' What follows in this *scholium* is directly attributed to Varro, and very possibly these words, too, are taken from the same source.

In works of art the double pipe is represented either as two straight pipes of equal length, or as two pipes of unequal length, in which case the longer pipe is always curved at the end farthest from the mouth, and terminates usually in a bell like the bell of a clarinet.

The curved pipe[2] is frequently mentioned in Roman writers, and usually in such a manner as to imply that it was of Phrygian origin, and although such an instrument is not found in any distinctly Greek work of art, the use of the curved pipe in Greece can be proved from the literature. Hesychius, s.v. *ἐγκεραύλης*, mentions this instrument, and calls it the Phrygian[1] pipe: *ὁ τοῖς Φρυγίοις αὐλῶν. ἔχει γὰρ ὁ ἀριστερὸς προσκείμενον κέρας*, as does also Athenaeus, IV. 84, *ἐν δὲ τῷ δευτέρῳ Φοίνικι ὁ αὐτὸς Ἴων φησιν "Ἔκτυπον ἄγων βαρὺν αὐλὸν τρέχοντι ῥυθμῷ" οὕτω λέγων τῷ Φρυγίῳ. βαρὺς γὰρ οὗτος· παρ' ὃ καὶ τὸ κέρας αὐτῷ προσάπτουσιν ἀναλογοῦν τῷ τῶν σαλπίγγων κώδωνι*, and Pollux, IV. 74, *Αὐλῶν δὲ εἴδη . . . ἔλυμος τὴν μὲν ὕλην πύξινος, τὸ δ' εὕρημα Φρυγῶν. κέρας δ' ἑκατέρῳ*[2] *τῶν αὐλῶν ἀνανεῦον πρόσεστιν, αὐλεῖ δὲ τῇ Φρυγίᾳ θεῷ.*

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[1] Pausanias, IX. 12. 5; Athenaeus, XIV. 31.

[2] Tib. II. 1. 85, Phrygio tibia curua sono; Verg. Aen. XI. 737, curua choros indixit tibia Bacchi; Ov. Met. III. 533, adunco tibia cornu (cf. Met. IV. 392); Ov. ex P. I. 1. 39, ante deum Matrem cornu tibicen adunco; Ov. F. IV. 181, inflexo *Berecynthia* tibia cornu.

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[1] There is a passage in the scholia to Vergil, in which a different explanation of the curved pipe is given: Servius ad Aen. XI. 737, *hanc tibiam Graeci* πλαγίαυλον uocant, *Latini uascam tibiam.* If, however, the πλαγίαυλος was a curved pipe, the explanation of it which has already been given (p. 14 sq.) is incorrect; for, with the exception of the little gold ornament there described, all representations of the transverse flute show perfectly straight tubes, and we are given to understand that the curve in this ornament was the result of accident. The very name of the instrument seems to indicate the manner in which it was held, and especially if we compare it with the Latin name *tibia obliqua*, which can scarcely mean anything else than transverse flute. Furthermore, both these names, πλαγίαυλος and *tibia obliqua*, are regularly used in the singular, as in Pollux, IV. 74, and in Pliny, N. H. VII. 204, obliquam tibiam Midas in Phrygia, (inuenit) geminas tibias Marsyas in eadem gente, and in such a manner as to indicate that the musician used only one of them at a time; while the curved pipe, although the name is used in the singular, is regularly represented in works of art as one of a pair, the other pipe being straight. It therefore seems fair to assume that the scholiast is mistaken in his statement, and that the curved pipe was really the Berecynthian horn which formed one of the pipes of the Phrygian pair, and particularly as this *scholium* is found only in the fuller commentary to Vergil first edited by Daniels, and is possibly of late origin. In only one other passage is there any mention of the tibia uasca (Solinus, 5. 19), and from this passage no further information can be gained.

[2] This is the most probable conjecture for the ἑκατέρων τῶν αὐτῶν of the Mss., although even this is inconsistent with the passages quoted from Hesychius and Athenaeus, in that it implies that both pipes of the pair were curved. I know of no ancient work of art in which both pipes are curved, although two old engravings, which claim to represent such works of art, do show both pipes curved. Both of these engravings are in P. S. Bartoli, admiranda Rom. antiq. uestig., Pl. 17 and 47, and the latter is reproduced, with the figure turned from right to left, in Bartolinus, de tibiis ueterum, p. 52. In the original relief, however, from which the first engraving was made, one of the instruments is straight (cf. Helbig,

The natural inference from this evidence is that the *impares* were always Phrygian pipes, exactly as was stated by Servius, and, furthermore, that one of these pipes was always curved at the end.

Pollux, IV. 80, describes the *γαμήλιον αὔλημα* as two pipes, of which one was larger than the other; and if this statement is correct, these pipes, according to the theory here advanced, were Phrygian pipes. It is to be feared, however, that, as has been surmised by von Jan,[1] Pollux has here explained as a variety of instrument what was merely a form of composition for the instrument, for *αὔλημα* is the name, not of an instrument, but of a composition. A possible explanation, however, is that this particular form of composition was always played on the Phrygian pipes.

The regular name in Greek for the Phrygian pipes seems to have been *αὐλοὶ ἔλυμοι*, as is shown by Athenaeus, IV. 79, *τοὺς γὰρ ἐλύμους αὐλοὺς . . . οὐκ ἄλλους τινὰς εἶναι ἀκούομεν ἢ τοὺς Φρυγίους*, and by the passage already quoted from Pollux.

In the didascalies to the plays of Terence there is no mention of the Phrygian pipes, but according to this view, the *impares* which were used to accompany the Heautontimoroumenos and the Phormio were, nevertheless, Phrygian pipes.

In performing on the Phrygian pipes, according to Hesychius (s.v. *ἐγκεραύλης*), the curved pipe was held in the left hand; and although the works of art give no conclusive evidence on this point, the curved pipe being represented now in the right hand and now in the left of the performer, there are reasons for assuming that Hesychius is correct in his statement. The Egyptian monuments, although they do not represent the Phrygian curved pipe, do show pairs of straight pipes in which one of the pipes is longer than the other. In all these cases the longer pipe is held in the left hand of the performer (Loret, p. 139). Again, if, as is implied by Servius in the passage quoted, the *impares* were always Phrygian pipes, the didascalies to the plays of Terence support the statement of Hesychius; for, although two right-hand pipes are mentioned in these didascalies, a pair of left-hand pipes is never mentioned. It would seem, therefore, that the

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Führer durch die öffentlichen Sammlungen Rom's, II., No. 805, note). The other engraving I have been unable to identify with any existing work of art in Rome. Possibly the author wrote *ἑτέρῳ τῶν αὐλῶν.*

[1] Baumeister, Denkm., p. 563.

musician never changed the instrument which he held in his right hand, but that, when the character of the music changed, he changed the pipe held in his left hand. Furthermore, Varro, as quoted by Servius, Aen. IX. 615, tibia Phrygia dextra unum foramen habet, sinistra duo, quorum unum acutum sonum habet, *alterum grauem*, implies that the left Phrygian pipe produced the lower tone, and, as the curved pipe is always longer than the straight one in the representations, it would of course produce the lower tone; and therefore, if Varro's statement is correct, the curved pipe was held in the left hand.

Theophrastus, H. p., IV. 11. 7, says that of the two mouth-pieces which are to be made from the same joint of the reed, the one towards the root was used for the left pipe, the one towards the top of the reed for the right pipe. If any inference can be drawn from this statement, it is that the pipe held in the left hand was intended to produce the deeper and more voluminous tone, for the internal diameter of the joint would be slightly greater in the part toward the root than in the other part.

As compared with the other forms of pipes, the Phrygian pipes are said by Porphyrius[1] to have had a bore of smaller diameter, and to have emitted much deeper tones. The latter of these two statements agrees exactly with what is known of the tone of the Phrygian pipe from other sources, in which stress is always laid on the deep tones[2] of the instrument.

SIZES OF PIPES.

The other main class of double pipes consisted, according to Servius, of a pair of pipes, equal in length and with the same internal diameter, '*pares sunt et aequales habent cauernas*,' but there is nothing in this statement which precludes the possibility of a variety of instruments composing this class. The works of art and the testimony of ancient writers show clearly that such variety existed, and even in ancient times there existed a general classification of the instruments, which has been used by Gevaert[3] as the basis of his description of the *αὐλοί*. This classification is found in Athenaeus,

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[1] Porphyrius, p. 217, ed. Wallis; cf. Plut. non posse suav. 13.

[2] Sophocles, frag. 468, *βερέκυντα βρόμον*, explained by Hesychius as referring to the Phrygian pipe; Athenaeus, IV. 84; cf. Eurip. Hel. 1349, *βαρύβρομον αὐλόν*; Aristoph. Nub. 313, *βαρύβρομος αὐλός*; etc.

[3] Hist. de la musique, II. 273.

XIV. 36, and is taken at second hand from Aristoxenus, περὶ αὐλῶν τρήσεως. Five classes of instruments are there enumerated, — the παρθένιοι, παιδικοί, κιθαριστήριοι, τέλειοι, and ὑπερτέλειοι, but in Athenaeus, IV. 79, the last two of these classes are called ἀνδρεῖοι.

This classification would seem to have been made with reference to the pitch of the instruments; for Aristoxenus (p. 28, ed. Marquard), after giving the range of a single pipe as two octaves and a fifth, says that the highest note of the παρθένιοι compared with the lowest note of the ὑπερτέλειοι gives an interval of more than three octaves, and evidently he is here comparing the two classes of instruments which show the greatest variation in pitch. In further proof of this may be quoted Aristotle, H. A. 7. 1. 7, where it is stated that the παρθένιοι were higher in pitch than the παιδικοί, and Athenaeus, IV. 79, where it is stated that the ἡμίοποι, which were the same as the παιδικοί, were shorter than the τέλειοι, and would therefore produce higher tones. As the ὑπερτέλειοι were used to accompany men's voices (cf. Pollux, IV. 81), the pitch was evidently lower than that of any of the other classes named.

Not all of the varieties of instrument mentioned in ancient writers can be classified with certainty, but so far as possible an attempt will be made to arrange them according to this scheme of Aristoxenus.

As pipes of very high pitch, which doubtless belong in the class of the παρθένιοι, are mentioned the γίγγροι[1] (Latin *gingrinae*), which were not more than a span in length, and gave very shrill tones; the *miluina*, described by Festus (p. 123) as *genus tibiae acutissimi soni;* the σκυταλία,[2] which were very short pipes; and probably also the παράτρητοι, of which Pollux (IV. 81) says: θρήνοις ἥρμοττον, ὀξὺ καὶ νωθὲς πνέοντες, and the νίγλαρος, Pollux, IV. 82.

The ἡμίοποι[3] were identical with the παιδικοί, and were shorter than the τέλειοι, as appears from Athenaeus, IV. 79. They were used at banquets. Probably the παροίνιοι also belonged to this class, for of them Pollux, IV. 80, says, σμικροὶ μὲν, ἴσοι δ' ἄμφω, τὴν γὰρ ἰσότητα συμποσίῳ πρέπειν. Gevaert adds to this class the αὐλοὶ ἐμβατήριοι and the δακτυλικοί mentioned by Pollux, IV. 82, the former of which was used in processions and the latter to accompany the hyporchemes; but it is doubtful whether such separate varieties actually existed, and Pollux says that by some they were said to be, not instruments, but forms of melodies, — which shows that he, at least, knew nothing about them at first hand.

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[1] Athenaeus, IV. 76; Pollux, IV. 76; Festus, p. 95; Solinus, 5. 19.

[2] Athenaeus, IV. 79; Pollux, IV. 82.

[3] Cf. Hesychius, s.v. ἡμίοποι.

The *κιθαριστήριοι* were used in accord with the lyre, as their name indicates (Pollux, IV. 81), and in this class ought probably to be placed the *μεσόκοποι*, which, as we are informed by Photius and Hesychius, were somewhat shorter than the *τέλειοι*: *ὑποδεέστεροι τῶν τελείων, καὶ ὄντες μέσοι.* Here belong also the Phrygian pipes, at least in Roman times, for Horace twice mentions them in connection with the lyre (Od. IV. 1. 22, and Epod. 9. 5), and, furthermore, the *μάγαδις αὐλός* (Athenaeus, XIV. 35–36). The testimony in the passage cited makes it clear that such an instrument existed and belonged to this class, although the word *μάγαδις* when used alone probably meant a kind of harp or lyre.

The *πυθικοί*, the instruments used in the Pythian contest, belonged to the class of *τέλειοι* (Pollux, IV. 81). According to Diomedes (p. 492, ed. Keil), these instruments were used to accompany the cantica of the Roman comedy.

The *αὐλοὶ ὑπερτέλειοι* were used to accompany men's voices, and were the lowest in pitch of all the instruments. In this class belong probably the pipes used in the temples; cf. Mar. Victor., p. 44, ed. Keil, 'spondaeus dictus a tractu cantus eius qui per longas tibias in templis supplicantibus editur, unde et spondaulae appellantur qui huius modi tibias inflare adsuerunt.'

There remain a number of varieties of the pipe which, in the absence of any testimony concerning their nature, cannot be classed with any degree of certainty; these are the *πυκνοί* (Poll. IV. 76), the *δίοποι* (Athen. IV. 79, Poll. IV. 76), the *ἰδουθοί* (Poll. IV. 77), the *βόμβυκες* (Hesych., s.v.), and the *ὑποτρῆτοι* (Athen. IV. 79), while the words *ὑπόπτεροι* (Poll. IV. 77) and *ὑποθέατροι* (Poll. IV. 82) are probably corrupt readings for *ὑποτρῆτοι.*

The *φῶτιγξ* is said by Athenaeus, IV. 78, to have been a form of *πλαγίαυλος*; its home was in Egypt.

The entire range of these five classes was, as stated by Aristoxenus (cf. p. 39), more than three octaves; and the classes themselves must have corresponded pretty closely with the ranges of the human voice, — soprano, alto, tenor, baritone, and bass, — as is clear from the names of some of the classes and from the direct statements about the others. Although the combined range of the five classes is nowhere stated, we can perhaps ascertain it approximately by the following method of reasoning.

The longest straight pipe which could be used, without keys to close the holes beyond the reach of the fingers, and produce a continuous scale, would be about 88 cm. in length; the hole nearest the lower end of the instrument would then be 78.1 cm. from the mouth of the performer. Such an instrument, if it belonged to the class of stopped pipes would give as its lowest tone G of our scale.

The shortest instrument mentioned in ancient writers is the γίγγρος one span or 22.18 cm. in length. A stopped pipe of this length would give as its lowest tone g' of our scale; an open pipe would give g''. Possibly Aristoxenus did not include these short pipes in his classification, for he seems to be speaking of instruments in ordinary use and the γίγγροι do not seem to have been instruments of this character. The normal range of soprano voices is given in *Riemann's Musik-Lexicon,* as from c' to a'', and it is not improbable that c' of our scale was the lowest note of the παρθένιοι as a class. The τέλειοι were probably about an octave below the παρθένιοι, for this is the normal interval between soprano and tenor voices. Their lowest tone would then be c of our scale; their length, if stopped pipes, would be about 62 cm.

The παιδικοί were also known as ἡμίοποι, a name which suggests that they may have been half as long as the instruments of some other class, perhaps the ὑπερτέλειοι. On this supposition their lowest tone was g; their length, if stopped pipes, about 44 cm. As the lowest note of the κιθαριστήριοι we might assume e of our scale, for one variety of this class, the μεσόκοποι, seems to have had a range midway between that of the τέλειοι and the παιδικοί.

It is further probable that within these different classes there were slight differences in pitch, and that, for example, not all ὑπερτέλειοι gave a tone so low as G of our scale.

Of the instruments in use among the Romans, those which have for us the deepest interest are the ones which are mentioned in the didascalies and in the commentaries to the plays of Terence, and it is desirable, so far as possible, to ascertain the exact character of these instruments.

In the didascalies the following names of instruments are mentioned: *tibiae pares*, *tibiae serranae*, *duae dextrae*, and *tibiae impares;* and this list practically coincides with the statements of Donatus at the beginning of the several plays. If it be assumed that these are all different instruments, there are at most four varieties; but as a matter of fact this number must be somewhat modified.

Placing side by side the statements of the didascalies and the statements of Donatus, which probably do not in all cases refer to the same performances of the plays, the following scheme is presented, in which I. represents the didascalies as they are found in the Bembine Ms.; II. the same, as they are found in the other Mss.; and III. the form in which they are preserved by Donatus.

	I.	II.	III.
Andria	———	———	paribus (dextris *ut* sinistris)
Eunuchus	duabus dextris	duabus dextris	dextra et sinistra
Heauton	primum imparibus deinde duabus dextris	primum imparibus deinde duabus dextris	———
Hecyra	tibiis paribus	tibiis paribus	tibiis paribus
Phormio	———	tibiis imparibus	tibiis serranis
Adelphoe	tibiis serranis	tibiis serranis	tibiis dextris id est Lydiis

Only in the case of the Hecyra is there absolute agreement in all three statements, — a fact which may be due to a change in the instrumentation of the other plays for later performances.

From Servius it has already been seen that the Serranae were *pares*, and the *duae dextrae*, as the very name indicates, must also have been *pares*. The *impares*, according to Servius, were always *Phrygiae*, and therefore the *dextra* and *sinistra*, if they differed in length, were Phrygian pipes *impares*, or, if they were of the same length, were *pares*. This reduces the actual number of varieties to three, which accords perfectly with the statement in Diomedes (p. 492, ed. Keil), where we are told that the comedies were accompanied by *pares*, *impares*, or *serranae*. Furthermore, in the treatise *de comoedia*, it is said of the comedies: agebantur autem tibiis paribus aut imparibus et dextris aut sinistris. Dextrae autem tibiae sua grauitate seriam comoediae dictionem pronuntiabant.

Sinistrae et serranae acuminis leuitate iocum in comoedia ostendebant, ubi autem dextra et sinistra acta fabula inscribebatur, mistim ioco et grauitates denuntiabantur. Two left-hand pipes are nowhere mentioned in the didascalies and, if the sinistra is the curved Phrygian pipe, cannot have been used as a pair, so that even Donatus seems to mean only three different varieties.

Of these three varieties the *duae dextrae* are said by Donatus, in the introduction to the Adelphoe, to have been the same as the Lydian pipes: modulata est autem tibiis dextris, id est, Lydiis, ob seriam grauitatem qua fere in omnibus comoediis utitur hic poeta. If this quality of *grauitas* is prominent in nearly all the plays of Terence, and if it can be expressed only by the Lydian pipes,[1] it seems necessary to assume that the pares mentioned by Donatus, in the introductions to the Andria and the Hecyra, were also Lydian pipes. In the *impares* the right pipe was perhaps the same as in the *duae dextrae*, the left pipe longer and curved at the end. The *serranae*, although *pares*, were probably both shorter than the *duae dextrae*.

METHOD OF PERFORMING ON THE DOUBLE PIPE.

In deciding how the musician performed on his two pipes at once there are three possibilities to be considered. He may have produced the same tone simultaneously on both pipes in *unison;* he may have produced tones separated by an octave; or he may have played the melody on one pipe and an accompaniment in accord, with smaller intervals than the octave, on the second.

The third of these methods seems the most probable, for the following reasons. The *αὐλοὶ ἔλυμοι* (*tibiae Phrygiae*) were, as has been shown, *impares*, or unequal in length, and consequently on one of them could be produced tones lower than could be produced on the other, but this was an absolutely useless feature in case the pipes were played in unison. Again, there would be very great difficulty in keeping the instruments absolutely in tune, as would be necessary in playing them in unison. Furthermore, a passage in Varro (rer. rust. I. 2. 15) shows conclusively for Roman times that the pipes were not played in unison: 'certe, inquit Fundanius, aliut pastio et aliut agri cultura, sed adfinis et ut dextra tibia alia quam sinistra, ita ut tamen sit quodam modo coniuncta, quod est altera eiusdem carminis modorum *incentiua* alia *succentiua*.

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[1] Acro (ad Hor. Carm. IV. 15, 30) assigns to the Lydian pipes a different character: Lydiis tibiis *laeta* canebantur, Phrygiis *tristia*. But in the commentary to Carm. III. 19. 17, both Acro and Porphyrio say that banqueters regularly danced to the music of the Phrygian pipes; and, as these instruments were also prominent in the orgiastic worship of Cybele and of Bacchus, it seems improbable that their music should have been of a very doleful character.

These words of Varro, it is true, might be applied to the second method of performance mentioned above, but assuming that the pipes were reed instruments of cylindrical bore and that each was provided with finger-holes enough to enable the performer to produce a continuous scale by the use of the harmonics, if the pipes were equal in length the range, when playing in octaves, would nevertheless be confined to exactly four tones and their semitones for each series of harmonics of the instrument; for, admitting the possibility of performing on two pipes at once, before the invention of the syrinx[1] it was impossible to produce simultaneously fundamental tones on one pipe and harmonics on the other, an operation which would necessitate blowing gently into one pipe and violently into the other at the same time. Either, then, the practical range of the pair must have been limited to four consecutive tones and their semitones, or the pipes were played in accord, with smaller intervals than the octave. It is inconceivable, from similar reasoning, that, with instruments of equal length belonging to the class of open pipes, the performer should ever have played in octaves.

Furthermore in the works of art the two hands of the performer are always near together, and this would never be the case when playing in octaves on stopped pipes. This method of representation was perhaps merely a conventional one; but it is difficult to see how the convention could arise if, in actual performances, the hands were always at considerable distances from each other.

The existence of polyphonic music in both Greek and Roman times can no longer be doubted,[2] and to judge from Plutarch (de mus., ch. 29), it was on the *αὐλός* that music in two parts was first performed. Apuleius, Flor. III., assigns to Hyagnis the honor of having first performed on his instruments music of this sort: 'primus Hyagnis in canendo manus discapedinauit, primus duas tibias uno spiritu animauit, primus laeuis et dexteris foraminibus acuto tinnitu et graui bombo concentum miscuit.'

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[1] With the 'speaker,' or syrinx, this difficulty is entirely obviated; and if the existence of this mechanism is admitted, there is no physical impossibility in playing the entire scale in octaves.

[2] Cf. Karl von Jan, in Fleckeisen's Jahrbücher, 1879, p. 583; R. Westphal, Die Musik des Griechischen Alterthums, p. 168 fg. The following passages I have never seen quoted in support of this theory: Boeotius, Inst. mus. I. 3, fin.,

It is only necessary to add that there is no unsurmountable difficulty in performing on such instruments as were found at Pompeii a simple melody and its accompaniment; the fingering of the instruments is the only difficulty, and that could be acquired by practice.

The accompaniment in Greek music, as is now universally agreed, was higher than the melody.[1] This is conclusively shown for the lyre by Aristotle, probl. XIX. 12, and it is safe to conclude that it holds true for the pipes as well. The same relative position of melody and accompaniment is still preserved in the music of the Greek church[2] and in much of the music of the early Christian church. The natural inference from this fact is that the melody was performed on the pipe held in the left hand; for, as we have seen above, in the case of the Phrygian pipes the longer instrument, and the one which would consequently produce the lower tones, was held in the left hand; and if on the Phrygian pipes the melody was performed with the left pipe, probably the same was also true of the other varieties of the instrument.

It is hardly conceivable that the Romans did not hold their pipes exactly as the Greeks did, more particularly as the art of playing on this instrument was believed by the Romans themselves to have been borrowed from the Greeks. The following passage from Varro (rer.

'Est enim consonantia dissimilium inter se uocum concordia'; id. ib. I. 28, 'Quotiens enim duo nerui uno grauiore intenduntur *simulque* pulsi reddunt permixtum quodammodo et suauem sonum, duaeque uoces in unum quasi coniunctae coalescunt; tunc fit ea, quae dicitur consonantia, Cum uero *simul* pulsis sibi quisque ire cupit nec permiscent ad aurem suauem atque unum ex duobus compositum sonum, tunc est, quae dicitur dissonantia.' In the experiments of Pythagoras, as described by Censorinus (de die nat., X. 10), it would seem that two pipes of different lengths were blown upon at the same time to produce the accord of the fourth, the fifth, and the octave.

[1] Westphal, Harmonik, p. 113; Gevaert, Hist. de la Mus., I. 364; K. von Jan, Jahrbücher, 1879, p. 583.

[2] Christ, Anth. Carm. Christ., p. 113.

rust. I. 2. 15 sq.) would seem, however, to show that the accompaniment at Rome was in his time played on the pipe held in the left hand: 'Certe, inquit Fundanius, aliut pastio et aliut agri cultura, sed adfinis et ut dextra tibia alia quam sinistra, ita ut tamen sit quodam modo coniuncta, quod est altera eiusdem carminis modorum incentiua altera succentiua. Et quidem licet adicias, inquam, pastorum uitam esse incentiuam agricolarum succentiuam auctore doctissimo homine Dicaearcho, qui Graeciae uita qualis fuerit ab initio nobis ita ostendit, ut superioribus temporibus fuisse doceat, cum homines pastoriciam uitam agerent neque scirent etiam arare terram aut serere arbores aut putare; ab iis inferiore gradu aetatis susceptam agri culturam. Quocirca ei succinit pastorali [L], quod est inferior, ut tibia sinistra a dextrae foraminibus.' The only difficulty lies in the last sentence, for no inference can be drawn from the first sentence, since the natural tendency would be to mention the right hand before the left, and further to mention the *incentiua* before the *succentiua*, as is indicated by the repetition of these words in the same order in the very next line. In the last sentence the word *pastorali* must be omitted, or *ei* must be changed to *ea*, as is shown by the context, *pastorum* uitam esse *incentiuam;* but the words *ut tibia sinistra a dextrae foraminibus* are incomprehensible. The use of the preposition *ab* with *inferior* is very unusual, if not unparalleled, and it is not impossible that the whole phrase beginning with *ut* is an interpolation.

The passage from Apuleius, Flor. III. (quoted on page 45), seems further to imply that the higher tones were produced on the instrument held in the left hand, the deeper tones on the one held in the right hand. In the words, 'primus laeuis et dexteris foraminibus acuto tinnitu et graui bombo concentum musicum miscuit,' *laeua, dextera, foramina* are clearly equivalent to *laeua, dextra, tibia*, and, unless we have in this passage a singular instance of chiasmus, the inference is unavoidable that the *acutus tinnitus* was produced on the left pipe, the *grauis bombus* on the right pipe. If, therefore, the accompaniment was higher than the melody, it must have been performed on the instrument held in the left hand.

It is very improbable that the Romans made any change either in the manner of holding the pipes, or in the relative pitch of melody and accompaniment, and therefore the conclusion seems inevitable that both Greeks and Romans regularly played the accompaniment on the pipe held in the left hand.

But the Phrygian left pipe was longer than the right, and therefore the accompaniment, if played on it, would at times be lower than the melody, if any use whatever was made of the lower tones. That the lower tones were used is indicated by Servius in the passage quoted on page 38, where he attributes to Varro the statement that the right Phrygian pipe had one hole and the left two, one of which gave a deep and the other a high tone. Although it is very improbable that the number[1] of finger-holes on either pipe was so small as is here stated, it is significant that both high and low tones are attributed to the pipe held in the left hand. The Phrygian pipes were a prominent feature in the orgiastic worship of Cybele and of Bacchus, and possibly in the music which accompanied this worship the accompaniment was performed on the pipe held in the left hand, and alternately rose above the melody and *droned* below it.

DESCRIPTION OF EXISTING INSTRUMENTS.

The instruments found at Pompeii in 1867, four in number, are straight tubes of ivory, which were originally covered with closefitting bands of metal, probably silver. This metal is in some places badly oxidized, and in a few instances has entirely disappeared; but, on the whole, the state of preservation is remarkable. Each tube has, at the end most remote from the finger-holes, a pear-shaped bulb, also of ivory, 3.8 cm. in length, into which is inserted a flaring tube of ivory, 3.5 cm. in length, provided with a socket into which the mouth-piece was inserted when the instrument was in use.

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[1] The use of the present tense 'habet' in this passage implies that this description of the Phrygian pipes applies to instruments in use in Varro's time; but it must be remembered that Varro, in stating that the tibia in ancient times had only four holes (cf. page 4, note), adds the statement that he had actually seen such instruments in the temple of Marsyas, leaving us to infer that all instruments in use in his time had a greater number of finger-holes. Not only is it incredible that any attempt was ever made to play a melody and its accompaniment on a pair of pipes such as is here described, one of which would have a range of two notes and the other of three, but the works of art which I have seen, with possibly a single exception, do not confirm this statement as to the number of finger-holes. The single exception is found in a relief on a sarcophagus in the Louvre, Fröhner, No. 300, where a bacchant is represented playing on Phrygian pipes. The curved pipe, which is held in the *right* hand, has two side-tubes near the lower end, but the straight pipe has neither tubes nor holes.

Although it is very improbable that the number of finger-holes was so limited as is indicated by this statement of Varro, it is not unlikely that the left pipe had a greater number of holes and a wider range of notes than did the right pipe. Festus, p. 109, says: impares tibiae numero foraminum discretae, and although I have seen but two works of art in which the pipes of a Phrygian pair differed in respect to the number of holes, in both cases the curved pipe had the greater number. These two works of art are a sarcophagus, No. 751, in the Lateran Museum at Rome, and the sarcophagus, No. 300, in the Louvre.

Through the kindness of the director of the Naples Museum I was permitted to examine these instruments and to make careful measurements of them, and from these measurements it is possible to reconstruct the ancient instruments and to ascertain by experiment their scales.

The bore of all four of the instruments is cylindrical and 0.95 cm. in diameter, the external diameter of the tube being in each case 1.42 cm.

The following measurements were all made with a standard rule measuring to the sixty-fourth of an inch, and were all repeated to insure accuracy. The measurements as given in the text have been reduced to the metric system from the original measurements in inches, which are added in the foot-notes. The distances were all measured from the lower end of the tube to the nearest side of the hole or band. In some instances the holes in the tube are still covered by the bands, and in such cases the measurement indicates the distance to the hole in the band and the diameter of the hole.

I. Catalogue No. 76891.

Total length, 49.68 cm. A, 4.28, diam. 0.63; B, 7.46, diam. 0.63; C, 11.74, diam. 0.63; D, 13.97, diam. 0.63; E, 15.87, diam. 0.63; F, 18.09, diam. 0.79; G, 19.52 to 21.9, a band in which no hole was visible; H, 23.49, diam. 0.79; I, 26.51, diam. 0.71; K, 28.74, diam. 0.79; L, on the under side of the tube, 31.75, diam. 0.79.[1]

Close to the bulb in this instrument is a narrow band, somewhat corroded, but which can be seen distinctly in the representation (Plate II. 1).

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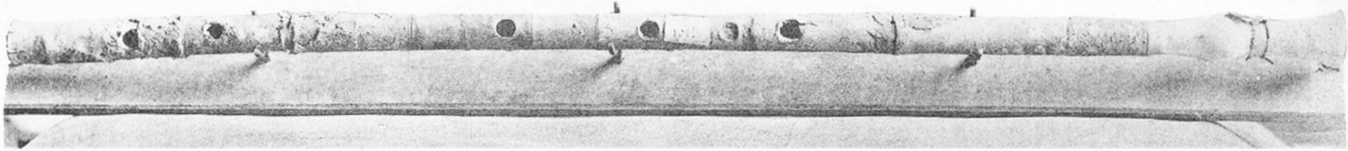
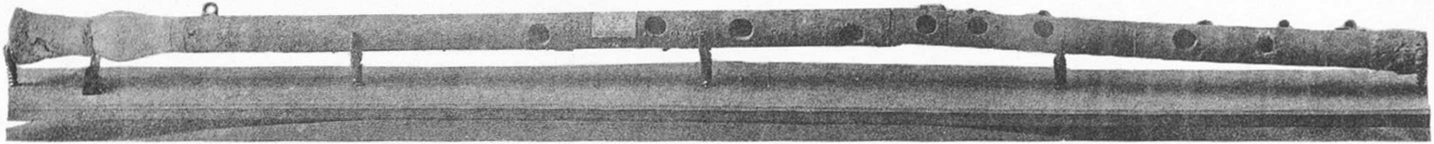
[1] Total length, $19\frac{9}{16}$. A, $1\frac{11}{16}$, diam. $\frac{1}{4}$; B, $2\frac{15}{16}$, diam. $\frac{1}{4}$; C, $4\frac{5}{8}$, diam. $\frac{1}{4}$; D, $5\frac{1}{2}$, diam. $\frac{1}{4}$; E, $6\frac{1}{4}$, diam. $\frac{1}{4}$; F, $7\frac{1}{8}$, diam. $\frac{5}{16}$; G, $7\frac{11}{16}$ to $8\frac{5}{8}$, a band in which no hole was visible; H, $9\frac{1}{4}$, diam. $\frac{5}{16}$; I, $10\frac{7}{16}$, diam. $\frac{9}{32}$; K, $11\frac{5}{16}$, diam. $\frac{5}{16}$; L, on the under side of the tube, $12\frac{1}{2}$, diam. $\frac{5}{16}$.

Plate II.


1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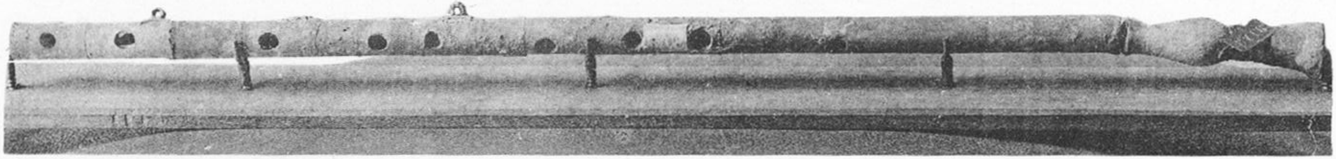
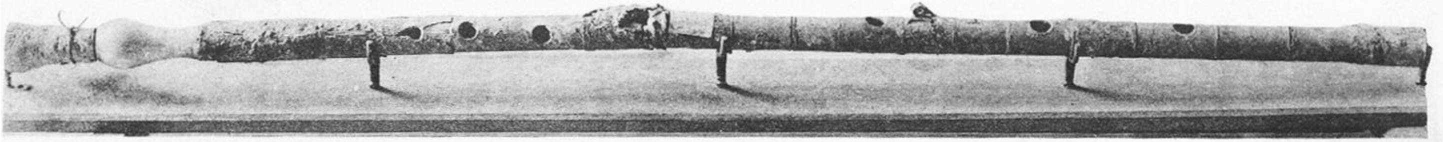

3


4

HELIOTYPE PRINTING CO. BOSTON.

The bands covering holes F, H, and I have traces of the mechanism described above to aid in turning the bands. This was probably the case with all of the bands originally, but the silver is so badly oxidized that the traces of the mechanism have disappeared. The holes C, D, and E are covered by the bands; the measurements are of the holes in the bands. In the other three instruments there is a hole corresponding to the band G in this instrument, yet I failed to discover any hole in this band.

II. Catalogue No. 76892.

Total length, 52.7 cm. A, a band 1.9 cm. wide, in which there is no hole; B, a band from 1.9 to 4.44, with turning mechanism, but no hole; C, 6.03, diam. 0.63; D, 9.20, diam. 0.87; E, 11.11 to 13.33, a band in which there is no hole; F, 13.65, diam. 0.79; G, 16.03, diam. 0.79; H, 18.09, diam. 0.79; I, 20.63, diam. 0.95; K, 24.76, diam. 0.95; L, 27.94, diam. 0.63; M, 29.21, diam. 0.63 (this hole is on the under side of the tube); N, 32.22, diam. 0.79.[1]

Close to the bulb on this instrument there is a band of silver 1.58 cm. in width and provided with the mechanism for turning. The silver is slightly oxidized, but close by the bulb is a hole in the tube itself not larger than a medium-sized pin. The band and the hole can be seen in Plate II. 2. The bands of B, C, D, F, G, H, have the mechanism for turning, although in the case of G there is only a trace of it still left. In each of the other instruments there is a hole corresponding to the band E of this instrument, which has no hole.

III. Catalogue No. 76893.

Total length, 49.21 cm. A, 1.27, diam. 0.63; B, 4.12, diam. 0.79; C, a band without hole or mechanism for turning; D, 9.68, diam. 0.79; E, 12.06, diam. 0.55; F, 13.81, diam. 0.63; G. 15.87, diam. 0.63; H. 18.09, diam. 0.63; I, 20.16, diam. 0.79; K, 23.33, diam. 0.63; L, 25.71, diam. 0.79; M, 27.95, diam. 0.63, on the under side of the tube; N, 30.95, diam. 0.63.[1]

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[1] Total length, $20\frac{3}{4}$. A, a band $\frac{3}{4}$ in. wide, in which there is no hole; B, a band from $\frac{3}{4}$ to $1\frac{3}{4}$, with turning mechanism, but no hole; C, $2\frac{3}{8}$, diam. $\frac{1}{4}$; D, $3\frac{5}{8}$, diam. $\frac{5}{16}$; E, $4\frac{3}{8}$ to $5\frac{1}{4}$, a band in which there is no hole; F, $5\frac{3}{8}$, diam. $\frac{5}{16}$; G, $6\frac{5}{16}$, diam. $\frac{5}{16}$; H, $7\frac{1}{8}$, diam. $\frac{5}{16}$; I, $8\frac{1}{8}$, diam. $\frac{3}{8}$; K, $9\frac{3}{4}$, diam. $\frac{3}{8}$; L, 11, diam. $\frac{1}{4}$; M, $11\frac{1}{2}$, diam. $\frac{1}{4}$ (this hole is on the under side of the tube); N, $12\frac{11}{16}$, diam. $\frac{5}{16}$.

The bands of B, D, F, G, H, L have the mechanism for turning, which has, however, almost disappeared in the case of D, F, and H. The holes E and H are still covered by the bands. This instrument is shown in Plate II. 3.

IV. CATALOGUE NO. 76894.

Total length, 53.65 cm. A, 1.4, diam. 0.63; B, a band without a hole from 2.54 to 5.08; C, 6.03, diam. 0.71; D, 8.89, diam. 0.79; E, 12.22, diam. 0.63; F, 14.28, diam. 0.79; G, 16.51, diam. 0.63; H, 18.41, diam. 0.63; I, 20.47, diam. 0.63; K, 22.70, diam. 0.63; L, 24.76, diam. 0.63; M, 27.30, diam. 0.64; N, 29.36, diam. 0.64; O, 33.17, diam. 0.64; P, 35.87, diam. 0.64; Q, 37.95, diam. 0.56.[2]

The hole Q, as can be seen from Plate II. 4, is now slightly elongated, but this is clearly the result of an accident; all of the holes in this and in the other instruments are circular, or very nearly so, and with very few exceptions the edges and inner surfaces of the holes are well preserved in all of these instruments.

There is no hole on the under side of this instrument, and consequently the engraving of it shown by Gevaert (Vol. II., p. 280) is incorrect in that particular, as also in the representation of hole A, which in the original is very near the lower end of the tube. Only the band of hole H has now the mechanism for turning the band, although originally most of the bands were doubtless thus equipped.

The holes A, C, E, G, H, I, K in this instrument are still covered by the bands. The metal casing near the bulb is so badly oxidized that it is impossible to say whether there was a separate band at this point, as in Nos. I. and II.

Each instrument has a separate band for each hole, or did have originally; but a careful search failed to reveal any band in which there were two holes as described by Gevaert (Vol. II., p. 646), although the fac-simile of No. II. in the Naples Museum does have one band in which there are two holes so arranged that both cannot be open at the same time.

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[1] Total length, $19\frac{3}{8}$. A, $\frac{1}{2}$, diam. $\frac{1}{4}$; B, $1\frac{5}{8}$, diam. $\frac{5}{16}$; C, a band without hole or mechanism for turning; D, $3\frac{3}{16}$, diam. $\frac{5}{16}$; E, $4\frac{3}{4}$, diam. $\frac{7}{32}$; F, $5\frac{7}{16}$, diam. $\frac{1}{4}$; G, $6\frac{1}{4}$, diam. $\frac{1}{4}$; H, $7\frac{1}{8}$, diam. $\frac{1}{4}$; I, $7\frac{15}{16}$, diam. $\frac{5}{16}$; K, $9\frac{3}{16}$, diam. $\frac{1}{4}$; L, $10\frac{1}{8}$, diam. $\frac{5}{16}$; M, 11, diam. $\frac{1}{4}$, on the under side of the tube; N, $12\frac{3}{16}$, diam. $\frac{1}{4}$.

[2] Total length, $21\frac{1}{8}$. A, $\frac{9}{16}$, diam. $\frac{1}{4}$; B, a band without a hole from 1 to 2; C, $2\frac{3}{8}$, diam. $\frac{9}{32}$; D, $3\frac{1}{2}$, diam. $\frac{5}{16}$; E, $4\frac{13}{16}$, diam. $\frac{1}{4}$; F, $5\frac{5}{8}$, diam. $\frac{5}{16}$; G, $6\frac{1}{2}$, diam. $\frac{1}{4}$; H, $7\frac{1}{4}$, diam. $\frac{1}{4}$; I, $8\frac{1}{16}$, diam. $\frac{1}{4}$; K, $8\frac{15}{16}$, diam. $\frac{1}{4}$; L, $9\frac{3}{4}$, diam. $\frac{1}{4}$; M, $10\frac{3}{4}$, diam. $\frac{1}{4}$; N, $11\frac{9}{16}$, diam. $\frac{1}{4}$; O, $13\frac{1}{16}$, diam. $\frac{1}{4}$; P, $14\frac{1}{8}$, diam. $\frac{1}{4}$; Q, $14\frac{15}{16}$, diam. $\frac{7}{32}$.

It is to be observed that no two of these instruments are of exactly the same length, but that I. and III. differ in this respect by only 0.42 cm., and that II. and IV. differ by 0.95 cm., while between I. and IV., the two extremes, there is a difference in length of 3.44 cm., or enough to make a difference in pitch with pipes of these dimensions of practically an entire tone. It would appear, therefore, that these instruments belong in two different classes. Experiments were first made with a pipe corresponding to No. IV. Into this a clarinet mouth-piece made from a slender rod of bamboo was inserted, in form like the one described in von Jan's article in Baumeister's Denkmäler. Repeated experiments showed that the proper length for the mouth-piece was not to exceed 5 cm., for with a mouth-piece of this length the complete chromatic scale can be produced through one octave and without the aid of the three holes nearest the mouth-piece. If these three holes are then opened successively, the second, third, and fourth of the octave can be produced; and then, with all the holes closed, the first harmonic of the closed pipe,[1] *i.e.* the fifth above the octave, is produced, which is the next note in the diatonic scale. It requires some skill and practice to produce this particular tone, but with care it can be produced. The harmonics of the tones produced from the other holes require far less skill, and the second harmonic, or sixth above the twelfth, can be produced from any of the holes without difficulty by slightly compressing the reed near its base with the lips.

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[1] Both Gevaert (Vol. II., p. 285) and von Jan (Baumeister's Denkmäler, p. 556) say that this is impossible without the aid of the 'speaker,' and the latter says: "Ein cylindriches Rohr von so einfacher Konstruction wie die aus Athen und Pompeji erhaltenen Auloi ermöglicht nach Aussprache der Sachverständigen für jeden Griff gar nur einen einzigen Ton," and farther on: "Ob nun jene Auloi eine andere Konstruction hatten als die von uns in Athen und Pompeji gefundenen Reste, oder ob die Kunstfertigkeit der Bläser auf denselben Resultate erzielte, die wir jetzt nicht nur praktisch sondern auch theoretisch nach den Gesetzen der Akustik für unmöglich halten, das lässt sich vorläufig nicht entscheiden."

It is, however, a mistake to suppose that the laws of Acoustics apply only to elaborately constructed pipes. These laws apply to all pipes, however rudely constructed; nothing could be simpler than the brass tubes with which these experiments were conducted, and yet I have repeatedly produced the harmonics on them, without the aid of a 'speaker.'

Even on the clarinet it is possible to produce the harmonics without the aid of the 'speaker,' although it is by no means easy, as I have been informed by a practical manufacturer of clarinets. The tube of the clarinet, however, has a much wider bore than that of these pipes from Pompeii.

The hole nearest the mouth-piece can be made to serve as a 'speaker' by turning the band so that the hole is but slightly uncovered, and it is not impossible that the ancient musicians helped themselves in this way until the 'speaker' was invented. The hole designated by A in the description of this instrument is so near the lower end of the tube that it has very little effect on the pitch when opened, although the effect can be easily noticed.

The scale of this instrument, compared with the standard pitch, is, d, ×e♭, e, f, f♯, g, g , a, a♯, b, c′, c′♯, d′, e′, f′♯, g′, and continuing in the first harmonic, a′, b′♭, b′, c″, c″♯, d″, d″♯, e″, f″, f″♯, g″, g″♯, a″, b″, c‴♯, d‴. In the second harmonic the following tones can be produced with ease, f″♯, ×g″, g″♯, a″ a″ , b″, c‴, c‴♯, d‴, thus giving this instrument a range of full three octaves, and fully confirming the statement of Aristoxenus as to the range of the pipe, while also confirming the statement of Proclus that three tones could be produced from each hole.

Experiments made by substituting an oboe-reed for the clarinet-reed were very unsatisfactory, and a bassoon or fagotte-reed was used instead. This reed, which is in form exactly like the oboe-reed, but considerably larger, produced practically the same results as did the clarinet-reed; the same continuous scale can be produced and the same harmonic series of tones — a fact which may be adduced as further evidence that the harmonics of the pipe are independent of the form of reed employed. With the clarinet mouth-piece, however, the tone is richer and fuller and the pitch of the various tones is more constant, for with the bassoon-reed the least variation in the pressure of the lips upon the reed causes a corresponding variation in the pitch of the note.

It seems impossible to decide which form of mouth-piece was actually employed on these instruments in ancient times, with possibly a slight probability in favor of the clarinet-type, which would insure greater constancy of pitch.

The scale of the instrument No. 76892, with a clarinet mouthpiece long enough to bring it in tune with the instrument just described (*i.e.* 0.95 cm. longer), is as follows: fundamental tones, d, e, f, g, g♯, a, b♭, c′, c′♯, d′, e′; first harmonic, a′, b′, c″, d″, d″♯, e″, f″, g″, g″♯, a″, b″; second harmonic, f″♯, g″ , a″, b″, c‴, c‴♯, d‴. It is to be observed that all of these tones correspond to tones which can be produced on the instrument first described — a fact which can be further illustrated by blowing on both pipes at the same time. The scale of the second instrument is, however, less complete than that of the first; the tones f′ and g′ of the fundamental series are lacking, as are also several of the semitones. There are two bands on this instrument in which I could discover no hole, and one of them corresponds exactly with the band of the f♯ hole in the instrument first described. The other band is provided with the mechanism for turning, and if provided with a hole would give the note e♭. If both these bands were provided with holes, the second instrument would lack only the tones b, f′, and g′ of the first instrument.

The scales of these instruments agree so exactly in respect to the other tones that it is at least conceivable that we have here preserved the two pipes of a pair, of which one for some reason had a scale less complete than the other. Gevaert (Vol. II., p. 280) expresses his belief that these instruments from Pompeii were intended to be used singly, and he is evidently influenced in this decision by the fact that these pipes have so large a number of holes. In fact, however, this is insufficient ground on which to base such a belief. As has been shown above, the double pipe was far more frequently used than was the single pipe, and to judge from the price paid by Ismenias,[1] these instruments were very expensive, which makes it improbable that four single instruments should have belonged to one man; and yet these pipes were all found together, and evidently belonged to the same musician. The pipe in the hand of the muse, Pl. I. 1, was one of a pair, and the number of finger-holes actually represented on this instrument is at least nine. Of the pipes shown on a sarcophagus in the British Museum one has seven, the other five, lateral tubes; and as these tubes are near the middle of very long instruments, and there is considerable space between the lowest one of them and the end of the instrument, it is natural to suppose that there were several finger-holes in this space, which the sculptor did not attempt to represent. There are many other reliefs and works of art, representing the double pipe, in which a similar space is shown, and, assuming that these representations are fairly correct, it is clear that the ancient musician often performed on two pipes each of which had a considerable number of holes.

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[1] Lucian, adv. ind. 5.

It is by no means certain that the two pipes of a pair of *pares* had each the same number of finger-holes, similarly placed, and, as a matter of fact, no two ancient instruments have ever been found which were exactly alike; but in the case of these two instruments the scales are such that with slight limitations they could be used as a pair, and it therefore seems not improbable that they were so used.

The instrument No. 76891, with a mouth-piece 4 cm. in length, gives the following scale: fundamental, e, f, f♯, g♯, a, a♯, b, d′, e′, f′, g′; first harmonic, b′, c″, c″♯, d″♯, e″, f″, f″♯, a″, b″, c‴, d‴; second harmonic, g″♯, a″, a″♯, c‴, c‴♯, d‴, d‴♯.

There is a band on this instrument which covers the proper position for a hole to produce the note c′, but no hole is visible in this band.

With a similar mouth-piece the instrument No. 76893 gives the following scale: fundamental, e, ×e, f, g, g♯, a, a♯, b, c′, c′♯, d′♯, e′, f′♯; first harmonic, b′, ×b′, c″, d″, d″♯, e″, f″, f″♯, g″, g″♯, a″♯, b″, c‴♯; second harmonic, g″♯, ×g″♯, a″, b″, c‴, c‴♯, d‴, d‴♯, e‴.

There is a band on this instrument in which no hole is visible, but which covers the proper position for a hole to produce the note f♯.

The hole 1.27 cm. from the lower end of this instrument has only a very slight influence on the pitch of the pipe — less than half a tone. The two instruments last described are of almost exactly the same length, differing in this respect by less than 0.5 cm. The scales of the two instruments agree with respect to a majority of the tones which can be produced, and where there is lack of agreement, the scale of one instrument supplements that of the other, so that by the aid of both a complete chromatic scale can be produced. There are missing, however, the holes necessary to produce the tones from g′ of the fundamental scale to b′, the lowest tone of the first harmonic series.

It is perhaps less probable that these two instruments formed a pair than in the case of the two instruments first described, but even here it is not impossible that we have preserved a pair of pipes of a different variety from the first pair.

The scales of the instruments as here given are in terms of standard pitch, and have not been changed to conform with the theory that the pitch of ancient times was a minor third below that of modern times.[1]

There are two instruments in the British Museum, of which a partial description has been given on page 16. These instruments, which were acquired by the Museum from the Castellani collection, consisted originally of an inner tube or lining of wood covered with a bronze casing composed of bands similar to those found on the instruments from Pompeii, but without the mechanism to enable the performer to turn them. The wooden lining has almost entirely disappeared, but enough of it is still preserved in one of the instruments to give an idea of the original form and of the diameter of the bore. The instruments are shown in Plate I., Figs. 2 and 3, and in the hole near the middle of Fig. 2 a portion of the wooden core is still visible.

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[1] Unfortunately, these scales do not agree with the scales given by Gevaert (Vol. II., p. 295) for these same instruments. The scales there given are raised a minor third, and still the lowest tone of each instrument is said to be d, which assumes an actual b (= h of the German notation) of the modern pitch (cf. p. 286).

I am inclined to think that the fac-similes of the Pompeian instruments on which the scales of Gevaert were determined are inexact, and for the following reasons. On page 280 it is said of the Pompeian instruments: "tous ont la même forme, la même dimension et ne diffèrent entre eux que par le nombre de trous dont ils sont percés"; and on page 286: "toutes quatre ont *la même longueur.*" As a matter of fact, no two of these instruments are of exactly the same length; the longest is 1$\frac{3}{4}$ inches, or nearly 4.5 cm., longer than the shortest.

To produce the note b in a stopped pipe the vibrating column of air should be about 66 cm. in length, and as the longest of these instruments is only 53.6 cm. long, it would require theoretically a mouth-piece nearly 13 cm. in length in order to produce this note, while, as Gevaert himself says (p. 292), the mouth-pieces were very small. The so-called fac-simile of No. 76892 in the Naples Museum does not have the narrow band and hole near the mouth-piece which is distinctly shown in Plate II. 2, and it has eleven holes, two in one band, while in the original, which I examined with especial reference to this point, I failed to discover any band with two holes.

It is for these reasons that I have ventured to disagree with Gevaert in his conclusions as to the scales of these instruments.

The lines which mark the divisions between the bands are not very distinct in the plate, a fact which is due to the unsatisfactory nature of the photograph from which the reproductions were made, but on close inspection the lines can be distinguished. One of the instruments is now broken just above the hole for the mouth-piece, and shows at the point where it is broken a portion of the wooden lining which originally extended from end to end of the tube. The other instrument, which is unbroken, is closed at the end above the mouth-piece, and undoubtedly the broken instrument was originally closed at this end. Mr. Arthur H. Smith, to whom I am indebted for the measurements of these instruments, thinks that both of them are broken at the end farthest from the mouth-piece; but inasmuch as the distance from this end to the mouth-piece varies in the two instruments by only one millimeter, and as this can hardly be the result of accident, it is probable that both instruments are practically complete at the lower end, and that the imperfect edge of the metal gave rise to the belief that they were broken.

In the measurements which follow the dimensions are all given in centimeters. The distance is given from the lower end of the instrument to the nearest side of each hole, and the diameter of the hole in two dimensions, the first lengthwise of the instrument, and the second measurement at right angles with the first.

V. Catalogue No. 84, 4–9, 5.

Instrument broken at the upper end. Length, 27.6; diameter at the upper end, Ext. 1.7 × 1.62, Int. 0.8 × 0.8, this being the diameter of the wooden lining which is preserved; lower end, Ext. 1.5 × 1.5, Int. 1.25 × 1.30 (the wooden lining has entirely disappeared at this end). Holes: A, 1.15, diam. 0.75 × 0.7; B, 4.3, diam. 0.8 × 0.78 (edge of the hole imperfect); C, 6.85, diam. 0.8 × 0.73 (edge of the hole imperfect); D, 12.12, diam. 0.75 × 0.78 (below, part of the wooden lining with hole, diam. 0.7 × 0.4); E, 19.1, diam. 0.8 × 0.72 (edge of the hole imperfect); F, bust of Maenad raised above the surface of the instrument, and above the forehead a hole slanting toward the lower end of the tube 24.4, diam. 0.6 × 0.6.

There is a separate band for each of the finger-holes, and in addition a band with no hole between D and E. All of the finger-holes in this instrument are on the same side of the tube.

VI. Catalogue No. 84, 4–9, 6.

Instrument closed at the upper end. Length, 29.8; diameter at the upper end, Ext. 1.52 × 1.6, the internal diameter cannot be ascertained as this end of the instrument is closed; lower end, Ext. 1.4 × 1.5, Int. 1.3 × 1.36. The wooden lining of this instrument has entirely disappeared. Holes: A, 1.0, diam. 0.55 × 0.55; B, 3.2, diam. 0.75 × 0.8; C, 6.8, diam. 0.6 × 0.55; D, 13.75, diam. 0.78 × 0.79; E, 16.0, diam. 0.83 × 0.76; F, 19.3, diam. 0.75 × 0.73; G, 24.5, hole for the reception of the mouth-piece exactly as in the instrument last described, diam. 0.63 × 0.62.

The hole E is on the under side of the tube, and was doubtless closed with the thumb; the other holes are all on the upper side of the tube. Each hole has a separate band, and there are two additional bands between C and D, but neither of them has any trace of a finger-hole.

In my experiments to determine, if possible, the scales of these instruments, I assumed, for the reasons stated on page 17, that they were reed-instruments of the πλαγίαυλος-type, and that the main bore of the tubes was originally cylindrical and 0.8 cm. in diameter, this being the internal diameter of the wooden lining where it is preserved. I used a very small clarinet mouth-piece, and connected it with the instrument by a rubber tube. With such an arrangement about 10 cm. in length, the note produced when all of the holes are open is the octave of the note produced when all are closed.

Although this mouth-piece is fully one-third as long as the instruments themselves, and is double the length of the one used with the Pompeian instruments, the results obtained are such as to justify the assumption that mouth-pieces of this length were used on these instruments. The scale of fundamental tones of instrument No. VI. is, in terms of standard pitch, a, ×a♯, ×b, c′, e′, f′♯, a′, and each of the last three notes can be lowered a half tone by partially closing the hole through which it is produced. The notes a♯ and b are a very little flat. The harmonics can be produced, and are those of the stopped-pipe.

With a similar mouth-piece the instrument No. V. gives the following scale of fundamental notes: a, a♯, b, c′, d ♯, a′, and by partially closing the proper holes d′ and g ♯ can be produced.

In the description of these instruments attention was called to the presence on each of one or more bands not provided with finger-holes. The single band on No. V. covers the proper position of a hole to produce the sixth, and the two contiguous bands of No. VI. cover the positions of holes to produce the fourth and the semitone between the fourth and the fifth. Similar bands without holes are found on the Pompeian instruments I., II., and IV., and on the instrument shown in Plate I. 1; but in every instance the band without a hole is placed between two other bands, each of which is provided with a hole.

Under these circumstances it is natural to suppose that the instrument-maker, to lessen the friction and the consequent wear of the instruments, made the movable bands with finger-holes narrow, and that, to prevent them from slipping up and down on the tube, he inserted between them fixed bands without holes.

This explanation does not, however, meet the case of the instrument No. VI., in which two contiguous bands are left without holes, since there is no apparent reason for inserting two fixed bands where one would be sufficient; and inasmuch as one of these bands covers the position of a hole to produce the fourth, the only missing tone in the diatonic scale, it has occurred to me that possibly this instrument is unfinished, and that when finished one or both of these bands would have been provided with a finger-hole. With an additional hole for the fourth, the complete chromatic scale could be produced on this instrument by the method of fingering suggested above.

The arrangement of the finger-holes on this instrument is such as to imply that it is a single pipe, and not one of a pair. There are two distinct groups of three holes each, one near the mouth-piece and the other at the lower open end of the instrument. The space between these two groups is so great that when either set of holes is closed by the fingers of one hand, only with great difficulty can a hole of the other group be covered with a finger of the same hand.

There are two other instruments in the British Museum which were found in a tomb near Athens, and were brought to London with the Elgin collection. These instruments are simple tubes of wood (sycamore), open at both ends, and each tube has six finger-holes, one of which is in each case on the under side of the tube, and was evidently closed by the thumb of the performer. No bands or other mechanical devices, and no traces of such arrangements, are found on either of these instruments. The main bore of the tubes, although not exactly cylindrical, is nearly so, and the instruments were certainly not conical pipes like the modern oboe, for in one of them it is the end nearest the mouth-piece which has the greater internal diameter.

The measurements of these instruments were made for me by Mr. Smith, and were made in exactly the same manner as were those of the two instruments last described.

VII. ELGIN INSTRUMENT A.

This instrument is not perfectly straight, but has somewhat the appearance of an elongated S. The length measured along the curvature is 35.6 cm., in a straight line 35 cm. The upper end is at present very much injured, and the sides of the pipe are pressed together; the internal diameter is 0.8 × 0.4. The diameter at the lower end is, Ext. 1.7 × 1.5, Int. 1.0 × 0.85. The distances to the holes are, as before, measured from the lower end of the instrument to the nearest side. A, 4.1, diam. 0.85 × 0.75; B, 9.3, diam. 0.95 × 0.75; C, 12.8, diam. 0.9 × 0.85; D, 16.3; diam. 0.94 × 0.78; E, 19. 4 (on the under side of the tube), diam. 0.9 × 0.73; F. 22.8. diam. 0.9 × 0.8.

VIII. ELGIN INSTRUMENT B.

This instrument is straight, and is 31.2 cm. in length. Diameter at the upper end, Ext. 1.45 × 1.20, Int. 1.25 × 1.03; at the lower end, Ext. 1.65 × 1.45, Int. 0.9 × 0.83. Holes: A, 6.4, diam. 0.9 × 0.73; B, 10.5, diam. 0.93 × 0.83; C, 13.7, diam. 0.93 × 0.80; D, 16.8, diam. 0.88 × 0.77; E, 20.4 (on the under side of the tube), diam. 0.88 × 0.73; F, 23.0, diam. 0.85 × 0.75.

These pipes are apparently reed-instruments of the same general type as those found at Pompeii, but are of much less elaborate construction. Without some arrangement for closing the holes not in use, they cannot have been used as a pair, since it would be impossible to close all of the holes of either instrument with the fingers of one hand. Furthermore, the pipes are of unequal length, and although the longer pipe is slightly curved, it has not the shape of the Phrygian pipe as shown in works of art; so that if it has been correctly supposed that the *impares* were always Phrygian pipes, these instruments cannot have formed a pair.

To determine the scales of these instruments I used a clarinet mouth-piece,[1] which, for the instrument No. VII., was made 7.4 cm. long, because with a mouth-piece of that length the note produced, when all of the finger-holes are open, is the octave of the note produced when all are closed.

The finger-holes of both instruments are oval and of large size, so that from each two tones can be readily produced, one when the hole is partially uncovered, the other when it is entirely open.[2]

The following scale of fundamental tones was produced, the letters in parenthesis indicating tones produced when the holes were only partially uncovered: g, (g♯) a, (a♯) b, c′, (c′♯) d′, (d′♯) e′, (f′♯) g′.

With the instrument No. VIII. I used a mouth-piece 8.2 cm. in length, and produced the following scale of fundamental tones: a, (b) c′, (c′♯) d, (d′♯) e′, (f′) f′♯, (g′♯) a′, (a′♯) b′. The harmonics can be easily produced on both of these instruments, and are those of the stopped pipe.

In order that the note produced with all of the holes open should be the octave of the note when all are closed, the instrument No. VIII. would require a mouth-piece over 12 cm. in length, and as such a mouth-piece would make this instrument longer than No. VII., it seemed necessary to adopt the shorter form here described.

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[1] The mouth-pieces with which the scales of all eight of the instruments here described were finally determined, were made exactly like the mouth-piece of an ordinary clarinet, but very much smaller. The opening over which the reed was bound was in each instance 2.3 cm. in length.

[2] Cf. Gevaert, Vol. II., p. 646.